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NOTES AND COMMENTS.

The British Cast-Iron Research Association.

An important meeting of the Midland cast iron industry will be held at Birmingham at the Chamber of Commerce on May 24, when Lord Weir, Sir Geo. Goodwin (President, Institute of Metals), and Professor Turner will speak upon the position of the industry.

We hope by the time this meeting takes place the position of Director of Research will be filled, as the time for applications closes on May 9. Obviously the success of the Association will rest on the choice of this man, who apart from his scientific attainments must possess organising ability and tact. On appointment the Director would do well to examine the research resources of the industry, as they are perhaps larger than would appear from a superficial examination, and a questionnaire sent to all foundries asking for details of the present arrangements for the carrying out of investigations would elicit much useful information. For instance, many Scotch firms use the Falkirk Technical Institute, whilst for Yorkshire much work is carried out by the Keighley Laboratories, Limited, a company formed by Keighley Engineering Employers' Association, and used by some 60 local firms. It should be the object of the Director to utilise, rather than run in competition with, such organisations. In various districts the needs are peculiar to the local trade, and there will always be room for such organisations as mentioned above. Researches on small textile castings would be of real use to the Lancashire district, but only of passing interest to the manufacturers of stove grate castings, but there is unlimited research which is equally applicable to every cast-iron foundry in the country. What little opposition which has been put up against the Research Association has been based on the need for local as against national investigations.

A Light Steel Castings Research Association?

A perusal of Mr. Holbyn's paper, which appears on another page of this issue, should convince the most optimistic of steel foundrymen of the need for research in this important trade. Evidently Mr. Holbyn's views are those of the automobile industry in general, as the following statement appears in the proceedings of the Institute of Automobile Engineers:—

"The author feels that the more he has to do with British makers of steel castings the more doubtful he becomes of ever being able to rely upon home productions. This particularly applies to *small* castings. The alternative of using a stamping cannot always be adopted, sometimes because the quantities required do not justify the expense of cutting dies, and sometimes because of the design. Efforts should be made to determine suitable mixtures which will give uniform results as regards physical properties of small steel castings, and the steel-founders should be asked to formulate their definite requirements as to the elements of design. The demand for small steel castings is becoming increasingly insistent, and the present unsatisfactory state of supply and quality cannot be allowed to remain. British founders can, and do sometimes, supply excellent castings, but the results sent out from some foundries are not always consistent, even from the same patterns. The reasons should be sought out in a spirit of co-operation."

We are not aware whether the scope of the Cast Iron Research Association could be enlarged to take in such work, but obviously the question is urgent. It has been frequently stated that mass production in the automobile industry has been rendered abortive through the inability to obtain a continuous supply of reliable steel castings.

STEAM AND ELECTRICITY IN STEEL WORKS.—An address on the subject of "Relative Cost of Rolling Steel—Steam *v.* Electric-driven Mills," was given by Mr. G. E. Stoltz before a sectional meeting of the Association of Iron and Steel Electrical Engineers in Youngstown, Ohio, recently. Mr. Stoltz based his statements on actual cost figures in various plants where the two different kinds of power are used, and he declared that electricity was the more economical form of motive power for rolling mills, regardless of size, and was more satisfactory in other respects. He stated that in the same way as electricity displaced steam as a power for the smaller units in iron and steel mills, the industry has reached the stage where the same development is taking place with respect to larger rolling units. It was pointed out that it is possible to conduct electric power economically over long distances for rolling mill use. The 84-in. and 132-in. plate mills of the Brier Hill Steel Company are supplied with electric power generated 18 miles away.

XUM

Synthetic Cast Iron.

The above term is a literal translation from the French, in which language it has reference to cast iron made from steel scrap in an electric furnace. Though a little similar work has been done in this country, the proposition, as it stands, is ruled out of practical politics on account of the relative dearness of current and cheapness of pig-iron and cast-iron scrap. The process was developed in France, Italy and Switzerland during the war, as conditions were such that the great hydro-electric stations provided an abundance of cheap current, the shell shops enormous quantities of turnings which were a glut on the market, and the German invasion very seriously reduced the quantity of pig-iron available. The process was found so simple and almost mechanical and produced such an excellent material that even though peace has brought about less favourable conditions synthetic castings are still greatly in demand. Generally speaking, the furnaces employed consist in a boiler-plate cylinder lined with firebrick and carbon, the hearth being similarly constructed and provided with a taphole formed as in cupola practice. No roof is provided, but one or three electrodes fill up most of this area. When one electrode is used there are generally three furnaces, each one being connected to one phase of a three-phase system. When three electrodes are used the Héroult system is represented. The electrodes are usually suspended from the shop roof and are automatically controlled by the Thury or similar system. Level with the top of the casing is the charging platform, the charges being weighed out and mixed on the ground floor and taken up to the platform by a lift. It can be safely asserted that these furnaces, providing the mixtures have been correctly weighed out, require no skilled workmen whatsoever. This statement has been made so repeatedly, when speaking of metallurgical or engineering specialities, that it requires some qualification. The writer has seen a furnace employed upon the manufacture of synthetic cast iron for remelting purposes which is worked continuously by four men and a boy divided over two shifts, the manager visiting the works on Sundays only. The one electrode furnace to which reference has been made makes 15 tons of castings per day, and gives hotter iron than the three electrodes type. This latter type takes current at 35 volts and 6,000 amperes on each phase.

The current consumption varies with the class of iron made, but the electrode consumption remains steady at about 11 lbs. per ton cast.

For carburising the steel scrap either anthracite or coke is used. Definitely established mixtures can always be relied upon to produce a definite cast iron at the same temperature. Some of these mixtures are given in Table I.

TABLE I.—SHOWING RESULTS OBTAINED FROM DEFINITE MIXTURES.

Material.	*Mixture Number.*				
	1	2	3	4	5
Steel turnings ..	1,000	1,000	1,000	1,000	1,000
Dry coke	200	160	120	80	70
Limestone	90	80	60	40	25
Silica sand ...	60	50	30	22	0
Fluor spar	5	5	8	8	7
Product.					
C 4.50	3.90	3.50	3.20	3.00	
Si 3.50	2.80	2.30	1.50	0.50	
Mn 0.60	0.60	0.60	0.60	0.60	
P 0.07	0.07	0.06	0.06	0.05	
S 0.001	0.001	0.002	0.002	0.002	
Power consumption, kw. h. per ton of iron melted ...	1,100	950	850	800	750
Basicity factor	0.90	1.00	1.10	1.20	1.40

$$\text{Basicity factor} = \frac{CaO + MgO.}{SiO_2 + Al_2O_3.}$$

The analysis of the materials employed were:—

Dry Coke.—Fixed carbon, 73.7 per cent.; ash, 26.3 per cent.

Limestone.—Calcium carbonate, 90.15; silica, 2.80; alumina, 0.7; magnesia, 2.10; ferrous oxide, 3.20 per cent.

Silica Sand.—Silica, 96.80; alumina, 1.25; ferrous oxide, 0.60; lime, 0.35 per cent.

Fluor Spar.—Calcium fluoride, 81.2; lime, 4.3; silica, 5.6; alumina, 1.10; magnesia, 2.10 per cent.

It will be obvious from the above that once the mixtures have been established they can be varied to give definite results with almost mathematical precision. Although the majority of the furnaces are not provided with roofs, the furnaces are really quite economical, as cold material possessing large surface area is constantly being charged, and robs the escaping gases of their heat. Though Paris can produce excellent castings, synthetic castings are being obtained from the Alps, and some Swiss synthetic iron castings are being used in the British automobile industry.

Queries Answered.

Hydraulic Cylinders.

K.1. When casting hydraulic rams of 11 in. outside diameter and 8 in. inside diameter and about 5 ft. long on end, I have found that even when using a mixture of 40 per cent. of hematite pig and 60 per cent. scrap, they machine too coarsely, having too open a structure. Please say what brand of iron should be used and what analysis should be tried for? For the hydraulic cylinders, which were about 3 in. thick for this job, I used the same hematite iron, containing 2.2 per cent. silicon, together with heavy scrap, which was definitely established as containing 1 per cent. silicon, and some semi-steel scrap, made from 50 per cent. steel and 50 per cent. of 1.5 per cent. phosphorus pig-iron, with the idea of "closing up" the structure by keeping the silicon down to about 1.5 per cent. It was suggested that semi-steel alone should be used, but I did not care to take this risk, as some semi-steel castings have turned out weaker than normal grey iron, probably due to the vagaries of the cupola fan.—"CYLINDER."

K.2. It is difficult to advise your correspondent as to the brand or analysis that he should use in the case he mentions; a great deal depends upon various factors. For this class of work, in which the thicknesses of metal are reduced to the extreme limit and the strength required correspondingly in order that the weights may be as low as possible, the choice of suitable irons is a very important matter. Some foundries use a mixture of two or three cold-blast irons together with one or two Scotch irons in equal parts. With such a mixture the fracture is found to be very close in the grain, yet not difficult to machine. Cylinder work demands a very strong and dense metal. Low silicon and total carbon are necessary with phosphorus medium; if low, it is an advantage so that segregation in heavy sections may be minimised. The steel scrap used should be heavy if your correspondent understands the art of gating to get his metal sound. The following analysis of iron has been used with advantage. For heavy castings: Si, 1.00; Mn, 1.00; S, 0.08; P, 0.20; TC, 2.85. For medium castings: Si, 1.50; Mn. 0.80; S, 0.05; P, 0.40; TC, 3.25.

Cylinders require to be close-grained, that is, with very small crystals, consequently, a low silicon pig-iron must be used along with just sufficient scrap to make them closer grained. If too much scrap is used it will weaken the metal on account of its higher sulphur content; the silicon in the pig-iron, however, must be high enough and the percentage of scrap must be so regulated that the castings will not be so hard that they will not machine readily. Your correspondent should know something about the composition of the scrap he uses. This neglect may be the cause of his troubles.

I do not advise him to make castings in "semi-steel" for this class of work. He will have a problem before him in running these high steel scrap heats. Only the best cupola and mould gating practice will yield castings free from blow-holes, etc. The silicon percentage will have to be watched, particularly so that separation of graphite and combined carbon may leave the latter low enough for proper machinability.—T. V.

Cast Iron.—I.*

The Strength and Properties of Castings.

By E. L. Rhead.

Many ironfounders and engineers yet fail to appreciate the value or meaning of a chemical analysis, which is in nearly every case a mere statement of the proportion of the elements present. The bare statement that cast iron contains certain percentages of carbon, silicon, manganese, phosphorus, sulphur, and other elements, does not convey any idea of the extent of the amount of the substances other than iron present in the metal.

Of these elements carbon is the only one that occurs in an uncombined state in the metal; of this element, a certain amount may separate in the free state, while the rest remains in a state of chemical combination in the metal.

When such combination between elements takes place the individual properties of the combining elements disappear, and they entirely lose their identity; the substance formed has distinct characteristics and produces effects as an entirely new body. Viewed in this light, the probable character of an iron will be seen to be greatly different from what it is when the amounts of foreign substance present are supposed to be indicated by the percentages shown by the analysis.

Carbon in combination is mainly present as the carbide Fe_3C. As this substance contains only 6.67 per cent. of carbon, the amount of carbide it represents is nearly fifteen times the weight of carbon in combination.

Silicon is present in combination with iron as FeSi or Fe_2Si, representing three and five times the weight of silicon present. There is no evidence of the presence of silicon in the free state.

Phosphorus is present as a phosphide Fe_3P containing 15.5 per cent. of the element, and equal in amount to 6.5 times the weight of phosphorus. It is all in combination.

Sulphur occurs as a sulphide of iron, or of manganese. The former has the composition FeS containing 36.3 per cent. of sulphur, and nearly three times its own weight of sulphide. The latter has the composition MnS containing 36.7 per cent. sulphur.

Manganese may be present as sulphide or carbide, or merely in solution in the melt. Considered in the light of these facts Table I. shows the composition of the cast-iron of the analysis stated:—

Table I.—*Showing the composition of cast-iron in terms of elements and compounds.*

	Percentage Composition.			
	Ultimate analysis.			Proximate analysis.
Gr.	.. 2.8			2.8 Graphite
C.C.	.. 0.5	(0.5×15)	approx.	7.5 Cementite Iron Carbide Fe_3C
Si.	.. 1.8	(1.8×3)	„	5.4 Silicide FeSi
P.	.. 1.0	(1.0×6.5)	„	6.5 Iron Phosphide
S.	.. 0.1	(0.1×3)	„	0.3 Sulphide of Iron
Mn.	.. 0.7			0.7
	Total .. 23.2			

Note.—The manganese present replacing iron in the compounds has been merely added. It does not indicate that it is present in the free state.

It will be recognised that the effects produced by the elements present must be far in excess of what might be anticipated from the amounts present, since their effects on castings are produced by these compounds.

The extent and nature of the effect depend on the behaviour of the compound with respect to the remaining uncombined iron and the manner in which it is associated with the substances of which the mass is made up.

I.—The substance may separate and assume an independent existence. In this case its effect will depend on the period at which such separation takes place.

(*a*) If it occurs while the metal is quite fluid it may subside or float to the top according to the relative specific gravity. Kish is separated in this way, as also is sulphide under certain conditions.

(*b*) The separation may occur during the period of solidification, in which case the free movement of the body will be impeded, so that complete elimination is impossible; but it will be entangled in the meshes of the solidifying mass, or segregated towards the still fluid portion, from which it subsequently may be finally separated.

(*c*) The separation may take place after solidification has been completed. Under these circumstances it must remain more or less intimately associated with the mass from which it has been separated, and the ultimate structure will depend upon the degree of liberty possessed by the particles under the conditions of separation. If at the period of separation the material is a molecularly rigid structure and molecularly impermeable, the freedom of movement of the particles will be reduced to a minimum or may be quite absent, and the separated body must remain in intimate association in the mass. If diffusion be possible, some degree of distinct existence may be attained. These phases are well typified in steel by the martensitic, sorbitic, and pearlitic states, and in heat treatment processes, where the modification of the heat conditions to which the materials are subject only limit or extend the period during which the conditions are such as to permit of the completion or sudden arrestment of some change. It applies to softening and annealing process for castings.

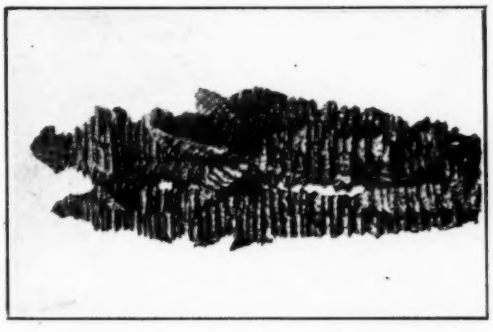

Fig. 1.—Crystallised Iron.

II.—The substance may not separate but remain in solid solution in the metal. In this case it may produce direct effects on the qualities of the metal by varying its hardness, crystalline form, tenacity, toughness, conductivity, and magnetic character, and also influence its behaviour with regard to other bodies present in the mixture, causing them to be retained in solution or rejected as the case may be.

When a substance assumes a separate existence in the mass, the properties of the bulk will be affected to an extent depending on the amount, the method of distribution in the mass, and the difference in properties between it and the mass from which it separates.

If it be collected in localised spots its effect will be confined to the areas in which it occurs. If distributed it will affect the whole in a manner depending on its state of aggregation, and the extent to which it interferes with the continuity of the structure. Thus flakes of graphite interposed in cast-iron cause weakness by breaking the continuity, being themselves brittle and having little adhesion to the iron grains.

From these considerations it will be seen that the strength of iron castings depends on many factors, and variations cannot be ascribed to one simple cause, whether of material or treatment. There is for every material a purpose for which it is best suited, and a treatment that will produce the best results. To obtain them, a knowledge of the behaviour of the metal and the constituents commonly present is necessary.

* Extracted from the Journal of the Manchester College of Technology.

The natural condition of iron is crystalline. Fig. 1 represents a crystal of nearly pure iron.

It ocurred in the cavity in the top of a steel ingot.

It measured about 12 in. in length, and was found depending from the top crust of the ingot. The primary form is a regular octahedron, and the elongation is the result of twinning. The occurrence of similar growths in cast-iron is not uncommon either in crystals of some size and regularity, or in the form of the so-called fir-tree crystals.

The mode of formation of such crystals is important, as it is closely connected with the strength of an ordinary soft casting and its behaviour in other respects.

Such crystalline formations are only exposed in cavities, but that is due to the ordinary process of solidification in thick castings, where the bulk of metal is sufficient to discount the rapid cooling action of the mould and ensure slow cooling, as shown by Fig. 2. This shows the effect of breaking a thick casting shortly after pouring. The greater part of the metal was still liquid and drained away, leaving a sponge of "fir-tree" crystals, which filled the cavity, showing that the action had penetrated through the mass. It will be observed that the rod-like components of the crystals are closely interlocked in every direction. This occurs in liquids in which no eutectic is found.

The formation brings forcibly to mind the character of the crystals of sulphur when they cool from fusion. The long needles of the element extend in various directions through the liquid. The form is probably produced because certain directions in the crystal are better heat conductors or discharge the energy of the fused mass more rapidly. In sulphur this action is most pronounced in one direction only, and long needle-shaped crystals occur. Iron crystals belong to the cubic system, and there are three directions all at right angles to each other. Every point along each of these directions may become an individual starting point, and rods parallel with those directions may be developed, building up finally, as the space becomes filled, a compact crystal. The rod-like structure of the incomplete crystals gives it its peculiar "fir-tree" appearance, and the interlacing character makes a continuous skeleton of reinforcement, as in reinforced concrete, which confers rigidity and strength, and ensures the distribution of externally applied forces throughout the mass. It is the purest, softest, and toughest portion of the casting. The occurrence of these crystals in cavities, and the frequently unsatisfactory character of the metal in which they are found, have led to some misapprehension. In the course of the cooling from fusion of a complex body like cast-iron many changes occur. It must be remembered that no substance can be considered apart from its effects on others. Its behaviour will be affected by the presence of and the amount of other elements present. This applies both to the iron and to the foreign substances it holds in solution when in the molten state.

In general, the presence of a substance in solution lowers the freezing point of the liquid, and the extent of the depression depends on the amount present.

Salt lowers the freezing point of water till the saturated solution of 23.5 per cent. only freezes at – 22 deg. C. With weaker solutions ice is formed at higher temperatures, but all below 0 deg. C. The ice contains no salt. This is left in the still liquid portion, increasing the strength of the solution. As the temperature is lowered more and more, pure ice is separated, and a stronger solution of salt remains, requiring a further lowering of temperature to produce further solidification. This continues till the residue contains 23.5 per cent. of salt and the temperature has fallen to – 22 deg. C. Any further decrease of temperature would cause the whole mass to become solid throughout. Such a solution is described as the eutectic solution. Additions of salt in greater amount than 23.5 per cent, raise the temperature at which solidification begins, but the substance that first separates is *salt*. This separation proceeds till the amount has been reduced to the eutectic composition, when further depression causes complete solidification as before.

Fused mixtures behave in much the same way. The melting point of pure iron is 1,580 deg. C., but the presence of silicides, phosphides, and carbides, and manganese, lowers this to an extent depending on the nature and amount of the substances present.

As the temperature falls the constituent which is less fusible and less soluble in the fluid mass begins to separate. In the case of slowly cooled unsaturated cast-iron containing only the usual amounts of impurity, this is nearly pure iron, or an iron-rich body, leaving a fluid residue containing a larger proportion of the other constituents. This is the crystalline skeleton previously referred to, and its rods will continue to grow in strength by the accession of material of a similar character as long as the solubility of the other constituents in the still fluid portion is below the saturation point. When the saturation point of any of the other components or solid solution is reached, they will begin to be deposited. The same changes will occur successively until finally a fluid residue will remain, which represents the most fusible mixture of the components of the magma. This will solidify as a whole. It is the eutectic mixture.

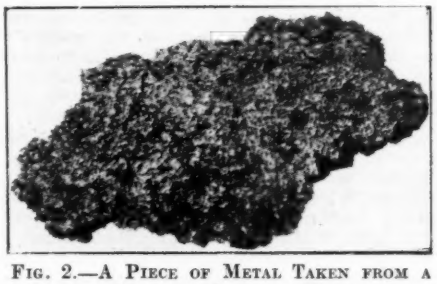

Fig. 2.—A Piece of Metal Taken from a Large Casting Broken Whilst the Greater Portion was Still Liquid, the Liquid Portion Having Been Drained Away.

In saturated iron the production of iron crystals does not occur, and the first separated constituent is a solid solution of iron carbide and silicide in iron, from which separates a more fusible portion, which contains the phosphide, and which solidifies at a lower temperature. Obviously the exact changes taking place at any particular point will be influenced by the cooling rate, and this by the shape and other conditions of the mould which will determine the rate and the direction in which heat will be most rapidly conducted away from the mass.

In rapid cooling there will be overlapping in the rate of separation of various constituents, and by extremely rapid cooling all may be retained in solid solution—that is, as intimately blended as when in the liquid state, and the development of the usual structure prevented. Thus a grey-iron may be transformed into a white-iron. Even in ordinary cooling some portion of the bodies which should remain with the liquid may be taken up and retained by the solid portion, and the completion of changes which should occur may be arrested.

It is, of course, the function of feeding to prevent the formation of such cavities by keeping up a supply of molten metal. Every substance that tends to depress the melting point tends to produce this effect. Although changes in structure in the solid state are possible, most of the granular character of cast-iron and the variation in composition that it represents are due to the mode of solidification and the formation of areas more or less isolated by the progress of the solidification. Each of these small areas thus becomes an independent portion in which the final stages and changes of the solidification take place. There is in the earlier stages, when communication is easier, and to some extent in the later stages, for the very fluid and most easily fusible eutectics, a tendency for them to be forced towards the centre of the castings, or where the greatest bulk of liquid exists; hence the openness of grain and large graphite flakes which occur in thick castings and the centre of iron pigs.

(To be continued.)

The Foundry and the Automobile Industry.*

By John B. Hoblyn, of Messrs. Vauxhall Motors, Ltd., Luton.

In any mechanism reliability is a *sine qua non*, and if reliability be sought, a sound material and sound design must be originally associated. Thus, for the component parts of motor cars—of which castings form a great portion—it is imperative that there should be correlation between the designer, the metallurgist, and the founder. Experience extending over many years seems to have led the founder to the belief that the training received by the average draughtsman has not included sufficient attention to pattern-making and general foundry practice; but while many draughtsmen have had to omit such considerations from their training, yet there are many others who have given careful study to the question, and who are in every way competent to appreciate the difficulties of the founder. In fact, the designer may claim that by the difficulty of his designs he has helped to enhance foundry practice, and to enable founders to make castings far more intricate than they would have been able to produce had the designer not firmly insisted on not altering his design. There is no question but that it is of increasing necessity for the designer and the moulder to come more closely together, for there can be no doubt that difficulties arise in producing castings which the designer may have missed, and a little guidance by the founder might help him to modify his design to enable patterns to be made, from which castings can be produced which depart only in minor detail from those he originally conceived. The founder is more familiar with change in volume on solidification and with constitutional changes that metals undergo in cooling, even within the solid range, through certain differences in temperature. His advice, therefore, upon the tendency for the formation of draws, etc., should have careful attention, for many times weaknesses are caused by both volume and constitutional changes which ensure the failure of a part before it is assembled in a car.

A differential casing, should be made with four cored holes, each of $1\frac{3}{4}$ in. diameter. For a long time a certain firm supplied these in good, sound condition, and then the patterns had to be removed to another firm. This firm, in order to obtain sound castings, persuaded the designer to allow the holes to be altered to $\frac{3}{4}$ in. diameter, to prevent drawing cracks. Here we have a case where one foundry can work well to the design, whilst another foundry requires the design altered in order to enable them to do their work efficiently. The author submits that it is not fair in such a case to lay the blame upon design.

This simple instance serves as a basis for a discusion of the general question of the simplification of design, for it is repeatedly asked that design be so conceived that it lends itself as an aid to the quick production of the parts; but there is one grave consequence that may arise if the designer accedes too much to this desire—the skilled man may be thrown back on the uninteresting performance of having to mould merely for quickness in manufacture.

The author believes, then, that the first thing necessary is mutual appreciation of their difficulties between the designer and the founder. Free discussions on the making of patterns will probably allow the founder to have these made so that he can make his castings his own way, and if he takes on the job under such circumstances, he cannot with justice want to blame the designer.

The automobile industry has in the past been built upon design that has made prolific use of castings, and what merit British cars have possessed must be shared by the founder; but there certainly are to-day many instances in which he might help us by remedying defective work. The author possesses sectioned cylinders that were cast before the war, where thin and thick sections are in close proximity, where the coring is difficult, and where $\frac{1}{4}$ in. thick metal has been obtained without apparently producing difficulties. The water ways in the cylinder head are particularly efficient, although they are very narrow in parts. He also possesses a section through a post-war cylinder—one of a large batch of defective castings—in which the water way has been made up by metal, and where the core has slipped in many places, thus causing a big difference in the thickness of the cylinder wall. The defect was found in the first place owing to the fact that leakage occurred in the cylinder walls when a pressure of 800 lbs. of water per square inch was applied. Inaccuracies such as these result in a diminished amount of water circulating in the cylinder head, and many times the boiling of water in a radiator—a phenomenon distasteful to all motorists, and the blame for which is always put upon the automobile manufacturer—may be due to such defective coring as has been instanced.

Faulty coring is also responsible for the formation of fins, which often occur inside cylinder castings, and which are a source of great annoyance. These fins, it may be said, occur with far more frequency in these days than they did in pre-war times, indicating that the moulder to-day is either less careful or less skilled than he was in those days. The formation of fins outside a casting is a common occurrence, but these are generally fettled before the casting leaves the foundry. It is significant that the cleanliness of a casting—other things being equal—may ultimately determine the destination of a contract.

Many automobile firms must have noticed that bosses on castings have sometimes been completely fettled out of position, and as these are often used as points of location, machining operations, when jigs are used, are completely upset.

Distortion is in these days a very common fault, and is, in many instances, of such a nature as to make one wonder why the foundry allows the castings to pass through its inspection department. It does appear that a more rigorous system of check and control is necessary, and the author would impress the fact that these are not by any means isolated examples; they are instances of many such castings that have been obtained during the past few years, and great toleration has been shown with firms that have supplied them.

Defects due to blowholes are, of course, too numerous to mention; and everyone can understand why blowholes and contraction cavities are caused, but the author fails to understand why foundries should send out castings with surface defects of this nature. It is obviously impossible to use them in high-class cars, and a large amount of annoyance would be saved if such castings were retained by the manufacturer. Many times, of course, these blowholes are not visible, and are only revealed after machining operations have been conducted, and then labour expenses, standing charges, etc., must be added to the general loss.

The following table gives the details of deliveries from a particular firm taken over a certain period some short time ago:—

TABLE I.—*Showing Percentage of Waster Castings Returned by an Automobile Company.*

Name of part.	Quantity received.	Rough view scrap.	Finished view scrap.	Total scrap.
				%
Differential cage ..	1,329	84	157	18.1
Spring saddle	1,062	109	23	12.4
Clutch plate presser ..	745	101	94	26.2
Cover for driving flange	543	87	26	20.8
Front hub	491	9	11	4.0
Back axle tube clip ..	1,354	35	2	2.75

Thus in some instances the amount of scrap is not large, and the author would appeal to founders to endeavour to make castings where the total scrap is of the order of the last two items mentioned. Although statistics are difficult to obtain, the author considers that an estimate of 25 per cent. of scrap in castings supplied to the automobile industry would be approximately correct.

* Read before the Sheffield Branch of the Institution of British Foundrymen.

The castings used in the past have been chiefly made of malleable-iron, grey cast-iron, and steel, but during the last few years aluminium alloys, manganese-bronze, and other non-ferrous metals have been introduced to an important extent.

The defects commonly met with in malleable-iron castings are:—(1) It is generally "volcanic," (2) it occasionally approaches white-iron in composition.

The last defect is a grave one. Every automobile manufacturer realises the difficulties the malleable manufacturer must meet with in controlling his operations from raw material to finished product, and the process needs as much accuracy and scientific control as any process known to metallurgical science, for it has so many governing factors. In times of quick production, however, the white-iron must be treated long enough in the annealing-oven to convert it into malleable, the time of treatment depending, of course, upon the size of casting, etc. Generally speaking, automobile firms ask for malleable in terms of tensile tests only, and they are not particularly concerned with the process by which the malleable is made. The firm with which the author is associated calls for the following tests:—Maximum stress, 20/22 tons per sq. in.; elastic limit, 13/15 tons per sq. in.; elongation, 12 per cent.; reduction of area, 12 per cent.

One sample sent from a firm gave the following tests:—Maximum stress, 27.6 tons per sq. in.; elastic limit, 17.13 tons per sq. in.; elongation, 13.5 per cent.; reduction of area, 23.1 per cent.

These were considered very wonderful figures, but it was realised that there is a big difference between making a *casting* in malleable and in making *castings* in the same material. Tests have been taken on many samples of castings of various sizes, and these do not approach the tests given by the sample. The author wishes to emphasise that tests of the order of 7.76 tons per sq. in. to 22.00 tons per sq. in. maximum stress have been obtained on many castings that have been cut up. Various tests have been obtained between these limits. It must be borne in mind that these figures are the only ones obtained when the bars were tested, and they lead to the belief that the manufacture of malleable-iron in this country still leaves a great deal to be desired.

Steel castings show far too great a variation in composition, and in some cases rejects have been found to contain as much as 0.7 per cent. of silicon in a steel of 0.22 per cent. carbon. There are still great difficulties with the thin section in steel castings, but these, no doubt, will in future be overcome.

Grey cast iron is about the most satisfactory of the castings manufactured when considered from a standpoint of composition, and the defects in this material are generally those indicated in the earlier portion of this lecture, namely, of a purely mechanical nature.

It seems to be necessary for the founders of ferrous-castings to realise that in the near future a fair amount of competition must be met in connection with the non-ferrous metals. Thus, with variable material like the malleable-iron that has been indicated, an automobile manufacturer begins to consider alloys like manganese-bronze, which the author knows has been bought to a specification that has consistently been met in the castings that have been tested. These tests in a manganese-bronze containing a trace of nickel were of the following order:—Maximum stress, 31.08 tons per sq. in.; elastic limit, 15.35 tons per sq. in.; elongation, 23 per cent.; reduction of area, 27.6 per cent.

Six months or so ago the respective prices of manganese-bronze and malleable iron were about the same, but at the present time, of course, the balance is in favour of malleable.

The heat-treatment of the steel casting is a matter that has not received the necessary attention, no doubt on account of the fact that complex shapes prevent those quenching and tempering operations that confer the best benefits upon this material; but there is no casting so poor but that its structure can be improved by some process intermediate between normalising and annealing. In fact, with suitable heat-treatment, steel castings can give very good tests indeed, and if care and attention be given to the manufacture of these there is certainly a big future for them. What is essential, however, is sound material and freedom from blowholes.

The author is aware that alloy steel castings have been made for some branches of industry, and in a heat-treated condition have given remarkably good results, but he is not aware of the manufacture of castings in this material for the automobile industry.

In America a large amount of attention has been given during the last few years to the so-called "semi-steel," and if founders in this country could produce a material of this nature which would machine well, stand 800 lbs. of water pressure per sq. in., and at the same time give a tensile test of about 22 tons per sq in., and a transverse test of about $1\frac{3}{4}$ tons per sq. in., there would be a possibility of the weight of cylinders being cut down somewhat. This consideration of weight reduction is a very grave one, and we must remember that the engine cylinder casting is one of the heaviest parts of the car, and any tendency to lighten it by an improvement in material, commensurate with sound economies in manufacture, would be very welcome.

One important consideration is economy in fuel consumption, and if cars can be designed giving a much more economic petrol consumption than is at present obtained a new era in motoring will take place. Undoubtedly for this the help of the steel manufacturer and the founder is required.

Regarding the commercial aspect of the relationship between the automobile firm and the founder, the author asks that, at the request of any firm placing orders with the foundry, the founder will supply weekly or monthly sheets giving the motor firm an idea as to how its orders are progressing. Thus it will have some definite fundamentals upon which to work in regard to expectancy of delivery. In the immediate past firms have worked more or less in the dark, and much of their progress work has consequently been hampered.

Rotary Table Sand Blast Machines.

Modern sand-blast machines of the rotary table type developed by the Pangborn Corporation, Hagerstown, Md., employ three different systems of blasting action. For work of larger character and most difficult to clean, the direct pressure system is used with the blasting action supplied by a direct pressure hose blast, and equipped with elevator and separator using both mechanical and exhaust means for reclamation and separation of the abrasive for re-use. The reclaimed abrasive is accumulated in storage bins from which the hose blast is instantly refilled through a quick acting valve that makes the operation practically continuous. Oscillating nozzles cover the entire surface of the blasting zone, which is entirely enclosed.

For work less difficult to clean or where the intensive action of the direct pressure is unnecessary the gravity feed type is equally efficient and permits of an entirely self-contained machine. Mechanical and exhaust action is used for reclamation and handling of the abrasive which is fed by gravity in a continuous cycle to the nozzles, where the full force of the air is exerted to the propulsion of the abrasive. This machine though made in but one size with table diameter of 84-in. has an adjustment of the nozzle arms that permits a clearance of 10 in. or 15 in. between the table top and nozzles, making it applicable to the widest range of work. Like the direct pressure the blasting action is entirely confined and movement of the nozzles covers every portion of the work within the closed zone.

For the cleaning of lighter work and requirements of refinishing, etc., the self-contained suction feed type provides a small compact machine. The used abrasive is reclaimed through screens and the handling is without elevator use. The cleaned abrasive is carried continuously by suction or syphon to the nozzles. The table diameter is 70 in. with clearance of 12 in. between the nozzles and table top, allowing for reasonably large work or a large quantity of small pieces.—"Iron Age."

Ruggles-Coles Rotary Dryers.

The Ruggles-Coles Rotary Dryer is designed to drive off free moisture, by the application of heat, from a large number of substances which may be raised to a moderate temperature. It is thus distinctive from a de-hydrator, which drives off moisture by mechanical means, and from a calciner, which drives off combined moisture by roasting at a high temperature.

As different materials require different treatment in drying, naturally no one type of apparatus can be adapted to all drying processes.

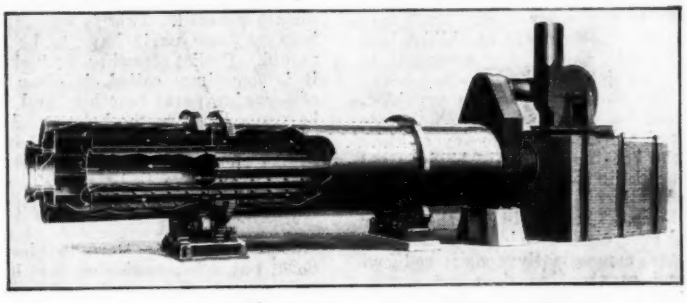

FIG. 1.—SECTIONAL VIEW OF A ROTARY DRYER.

The principle and the construction of this type of dryer are clearly shown in the sectional view in Fig. 1. It consists of two long concentric steel-plate cylinders set with the delivery end slightly lower than the feed end, the gases from the dryer furnace being taken down the central flue and then returned through the outer annular space, being finally exhausted to the atmosphere by a fan. On entering the inner flue the gases are reduced by the addition of excess air to a temperature of about 730 deg. C., and a great part of their heat is imparted to the inner shell, so that when they reach the outer shell they are at a temperature of 175 deg. C., while at exhaust they are reduced to 65 deg. C. The loss by radiation is therefore very small, since the outer shell is only in contact with cool gases, and the loss at exhaust is reduced to a minimum.

The material is fed into the outer annular space at the furnace end of the dryer. Lifting flights are provided on the inside of the outer shell, and these raise the material to the top of the dryer, thence dropping it on to the hot inner shell, where it is retained for the next half revolution by radial flights. The material in its wettest condition is therefore brought into intimate contact with the greatest source of heat. This operation is repeated over and over again, the material gradually working its way to the delivery end, due to the inclination at which the dryer is set. The moisture evaporated is constantly carried away by the gases, and the material while passing along its long spiral path through the dryer is continually raised in temperature, until just before discharge it comes in contact with the dry gases at a temperature of 175 deg. C. It will readily be realised, therefore, that the drying is in the highest degree uniform and efficient.

In addition to the thorough and efficient drying of the material, this type of dryer possesses another important advantage in that the highest mean temperature to which the material is raised does not exceed 175 deg. C., and can, if necessary, be kept well below even this moderate figure. Not only does this feature increase the efficiency of the dryer, since no heat is wasted in raising material to an unnecessarily high temperature, but the possibility of a change in the chemical composition of the material is obviated. High volatile coals can be dried even in dust form without serious reduction of volatile content or risk of fires, and fertiliser bases can be dried without decreasing the ammonia content.

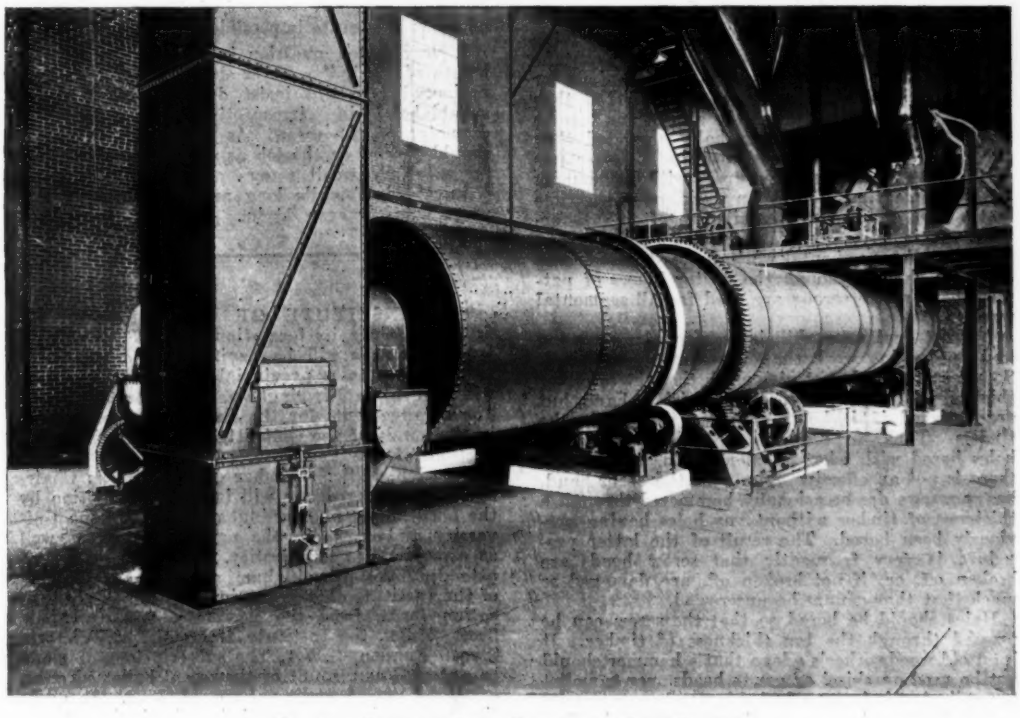

FIG. 2.—RUGGLES-COLES DRYER FOR SAND-DRYING.

General Construction.—In design, the dryer combines a simple and robust construction, with every necessary precaution to allow for unequal

expansion, to prevent back-spill at the feed head, and by the provision of air seals to prevent the useless loss of heat at the junction of rotating and stationary parts.

The inner and outer shells are rigidly connected midway by six cast-iron braces. Between these and each end there are swinging braces, which provide additional support and allow for the inevitable unequal expansion due to differences in temperature. This construction obviates stresses due to unequal heating, eliminating the shearing of rivets and loosening of joints.

The dryer is supported on two steel tyres, which are rivetted rigidly to the outer shell. Each tyre rests on four bearing wheels made of chilled iron ground to a true circle, these being arranged in pairs on rocker arms which are supported on heavy cast-iron bases. Two thrust wheels are provided, usually on the front base, as shown in Fig. 2, to prevent longitudinal movement of the dryer, while set screws allow the bearing wheels to be adjusted while the machine is in operation, so that the tyres can ride centrally on them without pressure on the thrust wheels. The weight of the dryer is thus distributed over eight bearing wheels, each having two bearings, consequently wear is reduced to a minimum and overheating does not occur.

Rivetted round the outer shell is a heavy gear ring which engages with a pinion keyed to the driving shaft. The driving base is arranged for a cross drive, but the driving shaft can be extended on either side or to the end of the dryer to suit local conditions.

The Ruggles-Coles Dryer is manufactured by Messrs. Electro Metals, Limited, of 56, Kingsway, London, W.C.2.

Some Notes on Wood Screws.

By J. Drinkwater.

Screws are far more often used than driving nails in the modern pattern-shop. They take longer to drive, but they are more convenient for loose pieces, if they are properly inserted they hold better than nails, and if alterations become necessary when a pattern is half completed they are more easily effected, because the various parts of the pattern can be taken apart without damage. At the same time, for cheap work, or when time is the first consideration, nails are often satisfactory. It is quite unnecessary also to use screws when building segmental work, unless the segments are very thick, although the writer knows of pattern-shops where screws are used for all segmental work.

A great deal more skill is required for screwing and unscrewing work than is commonly supposed. Some craftsmen do not give much thought to either thickness or length of screw for the job in hand, but are satisfied if it holds and does not split the timber. Thus, No. 8 screws are sometimes used in holes bored with what is called a No. 14 bit, and there is not an effective grip. On the other hand, heavy screws are occasionally hammered through a thickness of timber without any holes having previously been bored. The result of the latter procedure is very frequently that screw heads are broken off, or, if not broken off, are damaged so much that they cannot be unscrewed.

Holes should be bored so that the screw can be pressed through the top thickness of timber. It is an old woodworker's adage that a hammer should not be used on chisel or gouge heads, nor a mallet for nails, but it is not a bad thing to keep a special mallet for tapping screws, because there is then no danger of injuring the heads. For fine screws instead of using the shell bit the bradawl is frequently used, and a good bradawl for boring small holes in thin wood is one of square section; an ordinary bradawl that is ground square and tapering from the handle to a sharp point.

Some patternmakers use screws for adjusting flanges or other parts of a pattern. They find that when they tighten a screw and measure the work that it is too short, hence they "ease" the screw back a turn and get an accurate job. Even skilled men sometimes do this, and it is sheer bad workmanship. The part that is screwed is easily moved, and will almost certainly be rammed out of its correct position when in the sand. Packing behind flanges or other parts with paper or shaving is not a commendable practice, but assuredly it is better to do this and tighten the screw than leave a space. Generally speaking a counter-sinking gouge should not be used for screw holes, or, if used, the gouging should be done carefully. If screws are driven into dry timber, the thread is usually strong enough to take the head under the surface. When the screw head is sunk deep into the timber not only is the appearance inartistic, but if the pattern gets damp the screwhead is almost covered. This is exceptionally important, because loose parts have to be unscrewed in the mould. Pocket screwing, or "cheek" screwing, as it is sometimes called, is often a convenient way of screwing parts together, and the pockets should be gouged before the holes are bored, with plenty of clearance for the screwheads. There are few things more annoying than to find in the foundry that screws have to be prised up because the patternmaker has not left enough clearance at the back of the pocket.

Taking an old pattern to pieces is exasperating work, but it is astonishing that large patterns with frames and plates or barrels are not more often dissembled that the timber may be used again. If unskilled or boy-labour is used for this purpose and the salvaged timber can be cleaned at the planing machine it is quite profitable. It is when unscrewing loose pieces at the foundry or when dissembling old patterns that the value of grease is recognised. It is not too much to say that every screw used in the pattern-shop should be dipped into the tallow pot. In taking out screws that have become rusty, it is usually a mistake to hammer the head. Sometimes a careful tap will loosen the fibre, but it is much more effective to clean the screwhead thoroughly, and then tighten the screw slightly. The screw is thus loosened without damaging the slot edges for unscrewing. Hard hammering usually results in half the head falling off when it is quite impossible to get the screw out.

A very vexed question in pattern-shops is the length of "grip" a screw should have. Some experienced men will insist dogmatically that this should be ½ in., irrespective of the length or diameter of the screw. As a matter of fact it should depend on the job as well as the size of the screw. Very small screws only need 3-16 in. or ¼ in. "grip," while long and heavy screws may want 1 in. or even 1½ in.

THE INSTITUTE OF METALS.—For the first time since its formation, in 1908, the Institute of Metals will be paying in the autumn a return visit to a provincial city. This meeting will be held in Birmingham, on September 21-23. The arrangements for the September meeting are in the hands of the committee of the Birmingham Section of the Institute, of which Dr. H. W. Brownsdon, M.Sc. (Member of Council), is Chairman. The programme will include a reception by the Lord Mayor of Birmingham, visits to the University and works in the neighbourhood, as well as excursions in the locality. Persons desirous of attending the Birmingham meeting as members of the Institute should obtain the necessary application forms from the Secretary, Mr. G. Shaw Scott, M.Sc., the Institute of Metals, 36, Victoria Street, London, S.W.1. The subscriptions of members elected as a result of the recent ballot cover an extended period ending June 30, 1922. In addition to being able to attend the Birmingham meeting, members elected as a result of the ballot on April 20 will also have the privilege of being eligible to be present at the forthcoming eleventh annual May lecture. This special lecture, which is given each year by a distinguished metallurgist or engineer, is to be delivered at the House of the Institution of Mechanical Engineers, Storey's Gate, Westminster, S.W.1, on Wednesday, May 4, at 8 p.m., by Professor T. Turner, M.Sc., A.R.S.M., the subject of the lecture being "The Casting of Metals." Visitors' tickets are available for the use of non-members, and can be had on request being made to Mr. G. Shaw Scott.

The Failure of Metals.

The Papers read at the conference on the failure of metals under internal and prolonged stress, at the Institution of Mechanical Engineers on the 6th inst., formed the basis of a general discussion, of which we append a summarised report.

At the second session, following Dr. Rosenhain's introductory address, Mr. H. Moore (Woolwich Research Department) spoke in eulogistic terms of the address, describing it as an extremely clear and persuasive statement of what might perhaps be briefly termed the viscous flow theory of intercrystalline failure, and the evidence that this was the mode of failure in some cases was very strong. Although he (the speaker) thought that there were important cases of season cracking not explained by this theory, apart from this he agreed entirely with the address. During the last few years there had been a considerable extension of our knowledge of the subject of the failure of metals under internal and prolonged stress, a type of failure of which the season cracking of brass was probably the most familiar to users of metals. Our knowledge had been extended by experiments carried out to test particular theories, which had been of great value in this way, but was mainly the result of attack on the practical problems with which metallurgists had been faced as a consequence of the numerous failures of this kind occurring in engineering materials. There was a considerable body of experimental evidence indicating that in many cases of season cracking or similar failure the formation of cracks was due to the combined action of stress, initial or applied, and some other factor such as a selective chemical attack on the surface which was in tension. In the intercrystalline cracking of mild steel under the combined action of stress and hot solutions of certain salts the action appeared to be the same as in the case of brass, though the actual chemical reaction involved was different. Recently Dr. Rosenhain had quoted results obtained on certain aluminium alloys pointing to chemical action on the surface as a contributory cause of season cracking in that material, in which chemical action had not previously been suspected to be a factor. This encouraged him (the speaker) to suggest that chemical action might be sought as a contributory cause of cracking in other cases in which the evidence was at present lacking, and that such chemical action might be expected to exert the intercrystalline weakening effect now established in so many cases. It should not be assumed, however, that season cracking and similar failures were always the result of causes of the same type. If there were cases in which season cracking could be ascribed solely to viscous flow of an intercrystalline substance such cases might be expected to occur in metals and alloys at temperatures not too far below their melting point, since at such temperatures the viscosity of the intercrystalline material, according to the amorphous theory, was relatively low. It was difficult to imagine that in brass or steel at ordinary or at only moderately raised temperatures, the viscosity could be sufficiently low to permit of viscous flow, since the amorphous intercrystalline material, the super-cooled liquid, was so far below the melting point, and presumably had an extremely high viscosity.

Sir J. A. Ewing said that, as applied to crystals, "amorphous" simply meant that the atomic grouping was not the regular grouping of the crystal. This conclusion was supported by what they knew of the strength and modes of fracture which occurred in a metal consisting of an aggregate of crystals thus joined together. The ordinary process of yielding in a metal was a process of slipping in the crystals, and it was only in comparatively exceptional cases that the fracture became a fracture in which the boundary of the crystal took the principal part. In other words, it was only in exceptional cases that intercrystalline fracture developed. At low temperatures the material failed through slipping occurring within the crystals; at distinctly higher temperatures the material gave way by intercrystalline fractures.

Prof. Lowry said objection had been raised to the idea that under one set of conditions the amorphous phase was harder and more rigid than the crystalline, and in another set of conditions the opposite was the case. But that must be so. When one passed to the lower regions of temperature one got to the state where the amorphous phase had increased in rigidity very much more quickly than the crystal, and finally became the more brittle and rigid material.

Capt. Bengough described as a matter of common knowledge the fact that at high temperatures one had the fracture passing *between* the crystals, and at lower temperatures *through* the crystals. But this did not take them very far in considering what took place in that type of fracture known as season cracking, which might occur at quite low temperatures. As to the influence of chemical action in starting this condition, Dr. Rosenhain had suggested that the chemical action at the crystal boundaries was not likely to penetrate very far in between any two crystals because the products of corrosion of the intercrystalline cement would be found concentrating in the little trough formed between the crystals, thereby blocking out the oxygen. Corrosive action might be a very considerable contributory cause, though he was not prepared to go so far as to consider it the primary action.

Prof. A. W. Porter remarked on some of the observations made in respect to the properties of crystals. Crystals of ammonium nitrate were extremely plastic. One could take a single needle-like crystal of ammonium nitrate and tie a knot in it, but after that was done there was no evidence whatever that "slipping" had taken place. In reality there was another type of change which could occur in the case of some crystals a type which could be best described by regarding the crystal as becoming fluid, at any rate at certain points, under the action of the stress, and that when it had liquefied or semi-liquefied a rearrangement took place, with the ultimate formation of the crystal, still apparently of the same system, but of a totally different shape.

Prof. Lowry thought part of their difficulty was that they had always been brought up to believe in the crystal as an absolutely rigid thing, and it was difficult to eradicate that impression from the mind. Yet it was possible in some cases absolutely to bend the space lattice, to distort it in any way and tie knots in it, and that was quite a separate thing from the slip bands.

Mr. Stromeyer said that if iron crystals had different coefficients of expansion, both as regards temperature and elasticity, according to their different axes, one might get severer stress in one direction than in another. If that was so, those crystals which were overstrained in one direction due to cooling would give way when an additional stress was applied, although other crystals submitted to the same stress would not. That might account for the reason why mild steel had a low limit of elasticity, whereas harder steels—carbon steels—with their small crystals had a comparatively high limit of elasticity. The remarks made by Sir James Ewing about the change which took place at different temperatures—that at low temperatures the crystals gave way along slip lines, and at high temperatures it was the matrix which gave way—might account for that curious phenomenon in steel, brittleness at blue heat. He (the speaker) had examined sections of steel which had been subjected to treatment in blue heat, and had never detected any difference of crystal action in steel which had been made permanently brittle by that treatment of the original steel. But perhaps Sir James Ewing's explanation might fit the case, that the temperature of blue heat was the temperature at which the crystal did not know which way to slip. On the general question of brittleness and ageing, or season cracking, the important point was as to why steels and other metals did behave in this curious fashion. His own experiments on ageing had shown that nearly all steels, in fact all steels he had experimented with—and he had 27 samples—had distinct signs of ageing If he nicked the samples with a chisel he found that the older the sample the more easily the nicks cracked, showing quite clearly that there was an ageing effect in steel. Ageing could be produced by simply boiling. It was of the greatest importance for practical purposes to find out, not so much whether the action was a chemical one, but what metals did have ageing properties and what did not.

Mr. Spittal said that he had been somewhat disappointed in the trend of the discussion. He had rather expected to hear something about the means whereby the troubles which occurred from these internal stresses could be avoided. He trusted that they were not going away from the meeting with the feeling that all metal which had received cold work must necessarily season crack sooner or later. The bulk of the metal which was produced and put into use did maintain its condition for an infinitely long period. Otherwise all our permanent structures, our bridges and so on, must hasten to decay. At the same time it must be acknowledged that there were conditions where the metal for some reason failed, and failed rapidly.

Mr. O. W. Ellis raised the point as to whether atmospheric corrosion was not partially to blame for seasonal cracking in some cases. On the other hand, there were many cases of seasonal cracking which could be associated entirely with internal stress, as apart from corrosive action accelerating the effects of such stress.

Mr. Brayshaw said that hardened tool steel would sometimes crack after it had been kept, say, for one

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month. He had had in his hand a tool which had been hardened for a good many days, and which jumped in two with considerable violence and injured his hand. Tool steel would jump in two after quite a long period of time. He took it that in such cases a progressive change had been taking place all the time; in the case he instanced it was not a corrosion change. It was not necessary, however, that such change should take place in steel, for the old blades of steel from Damascus, one would think, had reached a fairly stable condition by now, and he believed that nothing further was happening to them. He would have thought, speaking as an engineer, that if the progressive change that took place was a change in volume of some portions, it would account for a great deal—one would have thought almost for everything—and if austenite changed into martensite there would be a change in volume which one would expect to be progressive over a long period. It was well known that a bar of hardened steel could be measured, and the change which took place could be watched day by day for a month, getting less as time went on, and if at the end of the month it was boiled in water for ten minutes a considerable change took place; a 6-in. bar of steel might easily change in length half a thousandth of an inch, due to the boiling alone. He took it that in such case there was a change in the volume. When the steel was hardened the outside was in one condition and the inside in another; the progressive changes that took place were different in the outside and the inside, and the change in the volume might account for the cracking. Furthermore, two pieces of steel could be treated in different ways, and then hardened in the same way, with the result that in one case there would be cracking and in the other not, though it was extremely difficult to see the difference between the one that cracked and the one that did not.

Replying on the discussion, Mr. J. C. W. Humfrey agreed with the amorphous theory, and with the necessity for a certain amount of plastic deformation to occur in the boundaries before seasonal cracking could take place.

Mr. Archbutt said a discussion had arisen as to whether the corrosive material accumulated in the boundary between two crystals would stop further action of the chemical agent. He wondered whether it had been considered that the material formed by corrosion—the oxide or chloride as the case might be—had a bigger volume than the material from which it was formed, and the accumulation of this chemical compound was quite likely to force those crystals apart simply because it had that greater volume.

Dr. Rosenhain said the discussion had centred round two points: (1) The amorphous phase and its existence in the intercrystalline layers, and (2) the prevention of seasonal cracking. Although the latter had been disputed, one came across many cases when one's work was connected with the study of failures as his happened to be. He thought it worth emphasising that, apart from the question of low-temperature annealing for the removal of internal stress, it was also possible to avoid the occurrence of much internal stress by the proper adjustment of the working operations. With regard to what had been said by some engineers in the discussion, he thought he had laid the bogey about the possible general failure of their structures. There were two reasons why they would not expect their structures generally to fail: (1) The rate of movement possible in the intercrystalline material of steel was very slow, and (2) the stress required to bring it about was very high. Then the stresses normally put in the structures were low, and therefore failure under those conditions could not be expected to occur. The configuration of the crystal boundaries had also to be reckoned with. Turning to the theoretical side of the question, which was none the less of very great importance from the practical point of view, a point had been raised by some speakers with regard to the products of corrosion. He knew that certain products of corrosion, so far from protecting the metal underneath, accelerated its further attack, but it did not follow that they all did, and he knew some which did not. They all knew that aluminium owed its very existence in an oxidising moist atmosphere to the fact that it coated itself with a film which was a product of corrosion. Then, in these minute interstices, things were in a very different condition from the layer of material on an open surface, and the conditions of diffusion existing there would be very adverse.

The general discussion was continued at the evening session, which was concerned with papers and discussion on the causes of failure of steel and brass. The question of steel was taken first, and a number of papers on this subject were under the chairmanship of Engineer Vice-Admiral Sir George Goodwin, K.C.B. (President of the Institute of Metals).

Dr. W. H. Hatfield said that with regard to Mr. Hanson's Paper, if one examined the rivet holes in a number of cases one did find numerous incipient cracks in corroding steel, and he thought it a fair question to ask Mr. Hanson whether he was quite clear that some of these cracks which were not of particular extent were not due to the corroding influence. With regard to the cracking of hardened steel, the author had suggested that the cracking was generally between the crystals. Probably in the cases the author had examined this was so, but as often as not, when hardened steel cracked, the cracking was not round the polygonal grains, but through them. Cracking was either due to unsymmetrical heating or unsymmetrical cooling.

Mr. O. W. Ellis said that during the war one of the tests which they applied at the Metallurgical Laboratory at Woolwich to quite a large number of different sorts of steel which they obtained from various makers was a hardening test. Steel of various sections was supplied to them, some of it up to as much as 8-in. square section, and while he was not suggesting that the method of testing adopted was entirely satisfactory, it was satisfactory in certain respects. In cases where samples of 6-in. square steel had been supplied, and these samples were hardened, rupture of the samples took place within a few hours if any piping was present.

Dr. Rosenhain said that the question of the intercrystalline cracking of steel was one of very great importance. Mr. Jones's experimental work on the subject was extremely interesting, but to conclude as he did—apparently from the fact that as much as 14 weeks' exposure in certain media did not lead to cracking—that some specific chemical action was needed to bring about cracking, was a little premature. Internal stresses were continuous in their action, while the working stresses were nearly always intermittent. Mr. Jones's Paper was a little misleading in its suggestion that the chemical action as a cause of such cracking had been definitely established already. In some experiments indications were obtained that possibly the influence of caustic soda did accelerate cracking of this kind, but it was not a very definite conclusion. One or two instances of actual failure in structures other than boilers had come under his notice, in which there were signs that intercrystalline failure had begun to occur.

Prof. A. W. Porter gave a brief experience of his own in regard to the action of salt solutions upon mild-steel plates. It was the case of an ordinary evaporative pan used for sodium chloride. The pan was about 80 or 100 ft. across, and when used for the evaporation of common salt solutions it gradually rusted through. These pans were used in practice until they were rusted through, so that finally they came to have the thickness of a sheet of paper. When such a pan, which had been used for a long time with common salt, was used for the evaporation of sodium nitrate solutions instead, it cracked within a few days. It did not rust at all under these circumstances, but simply cracked, and he had seen one that had cracked 100 ft. across.

Mr. Saniter described an experience of his own in the case of a tube which he discovered afterwards to have been "drawn to death" on a mandrel and not annealed at all. With regard to Mr. Rawdon's Paper, he believed that too great a degree of hardness was adopted in the case of American rails. There was one other feature of stress in steel. A good deal had been heard about dead soft steels, but it was a fact that in 3 per cent. nickel steel with a 40-ton tensile strength there was very great stress in some cases, and great difficulty in removing such stress.

Readers of the Papers having been called upon to reply,

Mr. Greenwood said that the only difference between internal and external stresses was that the former were due to the forces between the atoms, whereas the latter were due to any tension or compression externally applied.

Mr. Hanson said that Dr. Hatfield had given the impression that the intercrystalline cracking of hardened steel was a very unusual type of failure, but he did not think that that was quite the case. In reply to Professor Jenkin, most of the fractures of hardened steel which occurred in use were rapid fractures and were not intercrystalline; they were of the characteristic type which passed through the crystal grains. What he had referred to more particularly were cracks which took place gradually. In many cases these were intercrystalline in character.

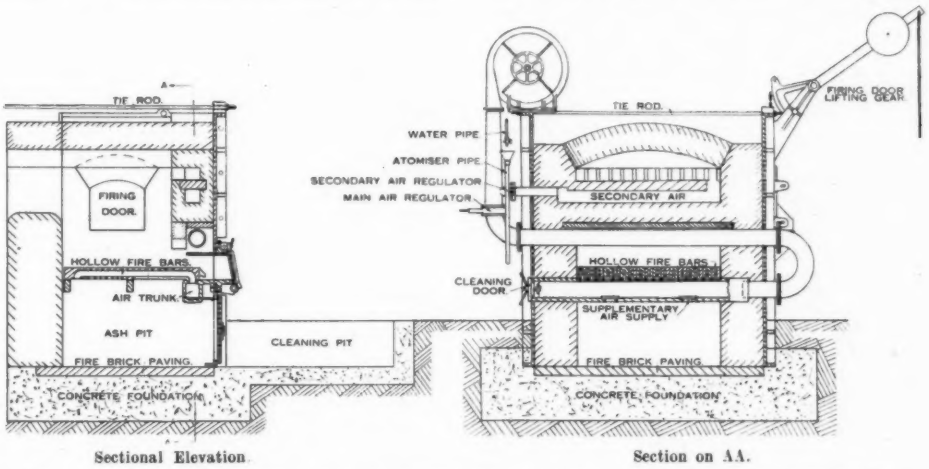
Sir Henry Fowler said a reference in Mr. Rawdon's Paper had reminded him of unfortunate experiences of his own in America with alloy steels which were full of what were called "snowflakes," a thing we did not have in this country.

Mr. Jones said that he had only a word to utter in reply to Dr. Rosenhain. He (Mr. Jones) had not said that these steels which he had exposed in certain media would not crack some time, but in nitrate solutions the cracking took place in two days.

The causes of failure in non-ferrous metals were then discussed, and a number of papers on the subject were read.

Producers for Drying Stoves in the Foundry.

It has long been recognised that a more efficient and economical method of heating drying stoves than by hand-fired with best coke is a real necessity. To this end many and varied attempts have been made to devise a producer suitable for this duty, and which at the same time shall be independent of a separate steam generator. Hitherto, however, to all such devices there have been inherent objections, either due to mechanical complications, inefficiency, or liability to breakdown. This last, a frequent source of trouble, is perhaps the most serious drawback, necessitating as it would holding up a portion, at any rate, of the foundry.



Sectional Elevation. Section on AA.

Fig. 1.—Priest's Saturated Air-Blast System applied to Furnaces, Boilers and Core Stoves.

The system and principle of working will be readily understood by reference to Fig. 1. The casing of the producer consists of strong tank-form plates securely bolted together and provided with the necessary feeding and cleaning doors. Mounted upon the top of the furnace casing is a motor-driven fan which supplies the blast through a valve-controlled air main. A drip of water, normally about a pint per lb. of fuel, is fed in so as to meet the air blast at a point below the controlling valve, the incoming water being swept along and broken up by the air blast through the pipe built in a wall of the furnace chamber, the blast being afterwards led by a U-bend below into a blast box, whence it is fed through hollow firebars of

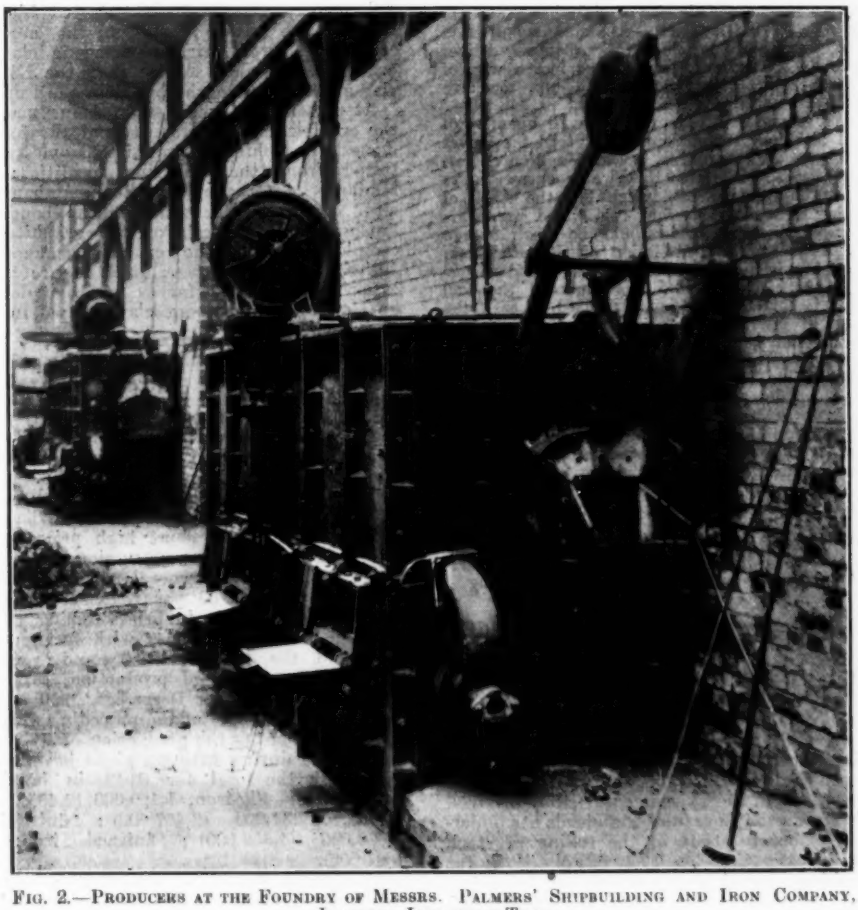


Fig. 2.—Producers at the Foundry of Messrs. Palmers' Shipbuilding and Iron Company, Limited, Jarrow-on-Tyne.

By the evolution of their system of saturated air blast, Priest Furnaces, Middlesbrough, appear to have solved the difficulty in a simple and effective manner, and with its adoption the producer becomes an entirely self-contained unit, equally suitable for installation in the smallest or largest foundry.

special design. The secondary air is admitted as shown; combustion being completed in the producer itself. The whole of the products of combustion are thus in the best condition to give up their heat to the stove, which is provided for through a distribution chamber consisting of a firebrick annular chamber built into the end of the stove, along which it extends for the full width and of a height equal to the producer. Ports are provided at floor level through which the products of combustion enter the oven chamber. The distributing chamber not only ensures an even distribution of heat throughout the whole of the oven, but it acts, to an extent, as a heat reservoir, as during the period of blowing the brickwork lining of the chamber becomes white-hot and this heat is given off into the oven when the producer blast is shut off, thus completing the drying by radiation.

By the courtesy of the management, our representative recently had an opportunity of seeing a number of the producers in service on the stoves in the metal foundry of Messrs. Palmers' Shipbuilding & Iron Company, Limited, Jarrow-on-Tyne.

It was in August last year that it was decided to test the producer on one of the stoves, which, like all the other stoves in the foundry at that time, was fired with best coke. The stove selected for trial, 20 ft. × 19 ft. × 8 ft. 7 in., was one with which considerable trouble had been experienced owing to windage, which at times meant that no charge was obtained. From the producer builder's point of view, also, this stove did not afford an ideal installation for the test, as, owing to space available and position, the producer had to be built on to one side of the stove. Even so, the installation fully justified the claims of Priest Furnaces, Limited; the stove showed considerable economy in firing, whilst its operation was of course entirely independent of the direction of the wind. As the outcome of the experiment, Messrs. Palmers decided to adapt the producer system to the whole of their stoves. At the time of our representative's visit, two further stoves had been so fitted, one 33 ft. 9 in. × 18 ft. 3 in × 8 ft. 10 in., and the second of similar length and width but 10 ft. 6 in. in height. In these instances two producers are built on to the end of each stove. The employment of a single producer would entail an excessively large grate area, which is undesirable; in practice, the most economic size of grate has proved to be about 4 ft. × 3 ft., which is the size employed in these producers. The fans for the producers deliver approximately 500 cub. ft. per min. against a w.g. of 20 in., and require approximately 2.8 h.p. to drive them, each fan serving two producers.

The producers are started up on a small quantity of coke, and although the makers guaranteed the stoves to work on good clean breeze, it was found on experiment by Messrs. Palmer that they would operate quite successfully on coke ballast, which had the effect of still further reducing the fuel cost. The producers are blown for about four hours, and the fans are then shut off. Prior to the installation of the producers, each stove required about a ton of best foundry coke for firing. As already stated, the bulk of the fuel now burnt is coke ballast, but expressed in cash the actual cost of producer firing is rather less than one-third of that of the old method, whilst there is a uniformity of output which, due to windage, was wholly impossible when the stoves were hand-fired.

The foundry floor at Messrs. Palmers is, on the one side, 16 ft. lower than yard level, and in order to put the producers on the back of the stoves on this side of the foundry, the whole of this ground has been taken out, whilst a ferro-concrete containing wall is being built to hold up the yard, provision being made at the same time for the storage of coke and ballast. The concrete and constructional work is being carried out by Sir Wm. Arrol & Company, Limited.

The two stoves in the brass foundry at Messrs Palmers' are also to be converted to producer firing.

EFFECT OF MECHANICAL TREATMENT UPON THE PROPERTIES OF STEEL.—The last-named of the three factors on which the properties of steel and many other alloys are largely determined—namely, composition, heat-treatment, and mechanical treatment—has received rather scant attention in the experimental study of steel. For this reason the Bureau of Standards has undertaken an elaborate study of the rolling of steel, and the investigation has been completed as far as the rolling operations are concerned. The test specimens are now being prepared for the different mechanical tests which, together with other examinations—such as metallographic—will be used as a measure of the effect of the various factors which enter into the mechanical treatment of metals.

Clays for American Graphite Crucibles.*

A U.S. Bureau of Mines investigation states that prior to 1914 practically all graphite crucibles manufactured in the United States were made from Ceylon graphite bonded with German Klingenberg clay. It was the general belief among graphite crucible manufacturers and users that good crucibles could not be made from American bond clays and graphites. Graphite crucibles were essential for melting certain alloys and special steels urgently needed for the manufacture of war materials. The demand for such metals was so great that it created an unprecedented demand for graphite crucibles.

Finding that the life of graphite crucibles was being shortened 15 to as much as 60 per cent., the ceramic station at Columbus, Ohio, undertook the investigation of American bond clays and graphites to determine their crucible-making properties as compared with foreign raw materials, and to furnish both crucible makers and users with much-needed information.

After the laboratory tests were completed fifteen large-size crucibles were made of each of the twenty clays, using a standard graphite. That the tests might be comparable to actual practice, the crucibles were made in the regular manner at the plant of the Vesuvius Crucible Co., Swissvale, Pa. Ten of the crucibles of each clay were tested under the regular foundry practice for melting brass at the plant of the Detroit Lubricator Co., Detroit, Mich., and five were tested under steel-melting practice at the foundry of the Simonds Manufacturing Co., Lockport, N.Y. Representatives of the ceramic experiment station were present during the tests and kept records of the performances of the crucibles. The results of the tests on the brass-melting crucibles showed that two American clays tested higher than the German Klingenberg clay and eight tested higher than the English clay. Tests on the steel-melting crucibles showed thirteen domestic clays giving crucibles of higher service than the Klingenberg clay and five testing higher than the English clay.

At present 120 crucibles are being made to test the crucible-making properties of the foreign and domestic graphites. Graphite samples are to be tested from the following localities: Ceylon, Madagascar, Canada, New York, Alabama, Texas, and Montana. The work on the bond clays is finished, and the tests on the graphites will be completed soon. The crucible makers of the United States have been quick to profit by these experiments. In so far as has been determined, no German Klingenberg clay is used in America at present.

Belgian Metallurgy.

According to official statistics recently published, the average number of furnaces in blast in January was 26, as compared with 27 in December, 1920, and a monthly average of 54 in 1913.

During the first half of 1920 Belgian metallurgy experienced a period of unprecedented prosperity, while abundant orders at high prices gave such added impetus to reconstruction work that by the end of July the general metallurgical production had reached 60 per cent. of its pre-war record. The decline in prices during the second decade, however, together with foreign competition and the decrease in demand, removed the stimulus for increased production, so that the production figures for December, 1920, show little variation from those of the preceding July.

Figures showing the production of iron and steel in Belgium during 1920 are given below, in metric tons, with the total for 1913 in brackets for comparison:—Pig-iron, 1,129,000 (2,485,000); steel ingots, 1,234,000 (2,467,000); finished steel, 1,072,000 (1,858,000); finished iron, 197,000 (304,000).

In Belgian industrial circles it is hoped that the restoration of the former preferential freight tariffs for ore transport by rail, and a diminution of production costs by wage readjustments, etc., will have a favourable effect on Belgian offers in foreign markets.

* U.S. Bureau of Mines *Reports of Investigations.*

Institution of British Foundrymen.

LONDON BRANCH.

Discussion on Mr. T. Vickers' Paper on the Co-operation of Scientific and Industrial Research in the Iron Foundry.

The Branch President (Major Gordon, O.B.E.) said where they got scientists they got mathematical precision, everything became more or less mechanical, and the old craftsmanship died out. Craftsmanship, as he understood it, of 100 years ago and to-day were two utterly different things.

Mr. W. E. Dobson said he was very interested in the author's remarks about the malleable trade, particularly when he heard that the Belgians were bringing back malleable castings to this country, because they were really buying malleable iron here. It was remarkable that they could do this and send their finished product back to this country, and perhaps this was accounted for by the quality. He would like to know whether Swedish malleable pig-iron was still largely imported in the Birmingham district, because in both France and Belgium a good proportion of that iron was frequently used. Another matter which had been well put by the author was the objection of the British foundryman to analysis. Having been in English, French, Belgian and German foundries, he was always very much struck by the difference between the points of view of the Continental foundryman and the English foundryman. On the Continent he was always able to discuss analysis, but if they talked to the English foundryman about silicon or sulphur he looked at them with suspicion. With regard to the question of fracture, one found a great objection here to machine-cast pig-iron, because the fracture appeared slightly denser.

Mr. H. O. Slater expressed his surprise at the lecturer's optimism in thinking that the English foundries would again take command of the world's markets in the malleable trade. He had been of opinion, from a certain amount of experience, that steel castings from electric furnaces and steel castings generally were taking the place of malleable castings owing to the expense of annealing, because by going through the comparative costs of cast iron and malleable cast-iron he had found that the latter were in some cases 50 per cent., or even 75 per cent., higher than grey-iron castings. He hoped some commercial and scientific men would excuse him when he considered it had been a great detriment to the malleable iron trade that it had been dealt with by people who understood little about it and sometimes offered the metal at a cheaper rate—probably through some firms not having a true costing system—than that at which it could be produced, or at any rate a figure below that at which a thoroughly good article could be produced. He knew of one concern which had adopted a costing system in which the whole of the non-ferrous metals were lumped together with iron and steel, and so long as a profit was shown on the year's working that was considered to be sufficient. But when the costs were worked out in detail it was found that the costs of producing malleable iron were higher than was anticipated, and they came as a shock to the firm concerned. He thoroughly corroborated the author's statement that malleable iron from a cupola certainly needed a higher temperature for annealing than malleable from either an oil- or coke-fired crucible furnace. He himself had produced malleable iron in a coke-fired crucible furnace. On changing to oil firing he had found that the material was greatly superior to that melted in the coke-fired furnace. He then changed to a cupola, and to his great surprise found that the final material was only half annealed. He was then at a loss to know what to do, but the only thing was to increase the annealing temperature, and by this means he got fairly good results. He had not the opportunity of using scientific instruments, but had to judge by the colour for the desired annealing temperature, and he still adhered to the opinion that an experienced man could judge accurately by colour. As was well known, different results could be obtained in different positions in the annealing furnace. With regard to tensile strength and elongation of malleable-iron bars—he supposed the figures given by the lecturer were taken from a bar—he had produced bars with a tensile strength of from 30 to 34 tons and an elongation of 3 per cent. He had a bar in his possession which he would like to test, and which he imagined would give a tensile test of over 30 tons, and that was produced from a cupola.

Mr. V. C. Faulkner said he agreed with the lecturer in everything he had said, except as regards the nomenclature "semi-steel." The word had been very thoroughly established, and he could not see that any person could object so long as "cast-iron" was understood. By using the word "semi-steel" as an adjective it correlated with the foreign terms. With regard to the Cast-Iron Research Association, there were several outstanding features which should be immediately investigated by this body. One of them was the well-known problem of sulphur in cast-iron. It was only common sense that if iron was being re-melted and re-melted every time it came into contact with coke it continued picking up sulphur. As the lecturer had pointed out, so far as one could see at the present time the only remedy would be to introduce electric furnaces, which, of their own natural agency, de-sulphurised in a very excellent manner. De-sulphurisation could be explained in a non-technical manner by pointing out the difference between the specific gravity of the sulphides of manganese and iron and the iron itself. If at a fairly high temperature the difference in the specific gravity in the two materials caused the one with the lesser specific gravity to rise to the surface, and, with suitable conditions, to be absorbed. One point upon which legislation was really required was with regard to the method used for annealing malleable iron. It was nothing more nor less than criminal to anneal cast-iron with coke or coal in the old-fashioned method: it was a most extravagant method of using the fuel, almost as bad as the kitchen grate, and ought to be superseded by more modern methods immediately. Some foundries had already done so, but there were still a great many using very old-fashioned methods. Another problem which required attention was that of the drying of sands. When sands came into the foundries they contained varying quantities of water. They came in open wagons, so that if the weather was wet they contained more water. That was a nuisance, and could be very easily eliminated by the installation of dryers at the quarries. With a modern dryer it would only cost a few shillings a ton to dry the material without destroying at all the plasticity of the clay, so that the foundries could always be certain of getting the same material.

Mr. A. R. Bartlett said the point which had struck him was that of the grading of pig-iron. In England we depended a lot on the method of grading by fracture. His firm had recently received some Belgian iron, and if the iron were graded by fracture he was afraid the results would have been misleading. He broke several pieces of pig-iron, and thought he had some idea of the chemical analysis by fracture, but when the iron was analysed he was surprised to find that the analysis was approximately what was offered by the makers. He was not able to give the actual results at present, but certainly the iron being delivered was coming out very near the statement of the manufacturers, and it had been a very great surprise to him.

Mr. Wesley Lambert said he had come to the meeting feeling in very good spirits, but the longer he stayed the more depressed he seemed to become. The author had represented how very much behind American iron foundry practice we were in Great Britain. He would like to ask the author whether he could say if the percentage of failures of cast-iron castings in America was really less than at home. Personally he had a very great admiration for the skill of the British foundryman. There may be very little science behind him, but he is certainly a very skilled craftsman.

The American Society for Testing Materials had recently drawn up specifications for cast-iron, but he did not see anything very surprising in them. The tensile and other tests specified were no better than those called for in British specifications, and actually complied with daily by British foundries.

One would have expected to find much more severe tests in the American specifications resulting from the vast amount of research work than the author has led us to believe is being done in that country.

If the recommendations of the American Cast-iron Research Association are communicated to the iron foundries, one would naturally conclude that with all the additional information and data afforded them there would be no difficulty in those foundries complying with a much more stringent specification than we are accustomed to work to in this country. He had no reason to believe that better tests were got in the American foundries than were obtainable in our own.

He was very pleased to hear the author mention the name of Dr. Percy. If any member has the opportunity of getting a copy of Percy's "Iron and Steel" from the public library he can see for himself the thoroughness with which the Doctor carried out his investigations, and would doubtless agree with Mr. Vickers that Dr. Percy was indeed one of the "brilliant lights" associated with the metallurgy of iron.

He did not propose to say much about malleable iron, because he knew very little about the malleable iron industry. The fundamental principle of the operation was extremely simple, and although very little science in respect to malleable iron work had filtered through to the workshops, a good deal of excellent work had been done in this country. He had had the opportunity of examining many malleable castings, and, on the whole, the "conversion" had been successfully carried out.

During the reading of the Paper he began to turn over in his mind some of the work which had been accomplished in the home foundries during the war. Without question the iron foundries throughout the kingdom "did their bit," and turned out some very fine work. He was of opinion that the foundries in this country were in a position to do good work if suitably encouraged. Many improvements are being introduced into foundry practice. Opportunity had been afforded him of visiting a very large number of foundries during recent years, and he unhesitatingly affirmed that there was a distinct improvement generally throughout the industry. The various managements were now awakening to the fact that a well-organised foundry was a very big asset in economic production.

Speaking more particularly concerning the cast-iron research work in which the author of the paper was interested, mention had been made of the important part electric furnaces were likely to play in the iron industry in the near future. He (Mr. Lambert) did not know whether it was within the author's knowledge that in the foundry at Woolwich two 6-ton electric furnaces, only recently erected, had been put up for sale. It may be assumed that the purpose for which they were erected no longer warrants these furnaces being retained, but he suggested that it may not be an inopportune time for the Cast-Iron Research Association to impress upon the Government the desirability of retaining the furnaces for research purposes.

A member asked the lecturer to indicate how it was proposed to get the co-operation of the employees in this matter into which the Cast-Iron Research Association was inquiring. This was a matter upon which he held very strong opinions, and it was an element which was, perhaps, the most important to all, because without that co-operation there would not be much progress. He felt curious to know how that co-operation was going to be brought about, because he believed there were many people who would be only too pleased to interest themselves in this matter if the opportunity offered itself.

Mr. T. D. Robertson congratulated the author on his Paper. He had made it clear to all that there was a real necessity for scientific co-operation in the foundry industry. One thing had struck him very forcibly, and that was that the author had said that the average output of the American malleable iron foundries was something like twelve times that of the average malleable foundry in this country. He wondered what individual opportunities all the small foundries in this country had of making investigations on their own account, and was it not an absolute necessity for the whole of them to co-operate in one organisation for the carrying out of research such as was proposed by the Cast-Iron Research Association. Mr. Vickers had made it clear that there was a big scope for improvement in the quality of all our iron castings. When a student he was told that a poor quality casting had a tensile strength of something like 5 tons per square inch, an average casting had a tensile strength of 10 tons, and a very good one 15 tons. These figures had stuck in his memory, but it seemed to him that a material which might vary between 5 and 15 tons per square inch in tensile strength was a material to which a great deal of thought should be devoted, in order that its highest qualities might be developed. Several speakers had mentioned the electric furnace, and he should say that in America now there was—and he believed there would be in this country in the future—a good deal of attention devoted to the subject of improving the quality of cast iron by refining in electric furnaces. It was a simple proposition from the electric furnace point of view, and it was one which could be carried out at a relatively low cost, and there was no doubt that the sulphur in cast iron could be most effectively removed, and cheaper mixtures of iron could be used for melting in the cupola prior to refining, which would give very strong castings indeed. The temperature of that iron could easily be raised, and the iron could be made into castings more easily than was the case with similar mixtures merely melted in the cupola. With regard to the term "semi-steel," Mr. Faulkner had submitted reasons for its applicability, and that everybody understood it. During the war he (the speaker) was in Australia, where steel scrap was very cheap and plentiful, and suitable pig-iron for making grey-iron castings was scarce and dear. It was the general practice there to melt nothing but steel scrap in cupolas, and to add a certain amount of ferro-silicon in order to make the resulting iron sufficiently soft. Surely "semi-steel" was a misnomer when applied to such a material.

Mr. W. A. Naish, A.R.S.M., A.I.C., said that, without wanting to appear disrespectful to the older members of the industry, he submitted that there would not be much active support from them, at all events in the matter of technical education in foundry work. His idea was that they ought to get to the younger people, and in this way could improve the status of the whole trade.

As to research itself, he thought the newly-formed Association could, and would, interest the employers in many of the ways so ably put forward by Mr. Vickers, and thus we might anticipate a state of things whereby the employees were improved by reasonable technical education, and the employers were supporting and benefiting by supporting the Research Association, and it would not be very long before we should see a big advance in the foundry industry.

The Author's Reply.

Mr. Vickers, in reply to the discussion, thanked the speakers for the kind and lenient way in which they had discussed the Paper. There were two phases of the research work—the research itself and the Bureau of Information. The latter was the part which he personally had in hand, and which comprised the collection of data from every part of the globe, and would comprise technical matter in all languages and forms, and should enable them to bring British foundrymen thoroughly up-to-date. The collection of this data had already commenced, and, if they were to see some of it, they would not be at all surprised that other countries were so far ahead of us in their foundry methods.

The first point raised in the discussion was in regard to the question of pig-iron in Belgium. The Belgians had obtained a large number of orders from this country for malleable castings. In one case, in which a large consignment of Belgian malleable iron had been delivered, the purchasers had been told by the manufacturers that they could supply double or treble their present output if we could supply them with the pig-iron. British pig-iron was being sent to Belgium, and came back in malleable parts cheaper than they could be made here. Inquiries made to ascertain why this was so were met with one fact which we in this country could not get over, and that was that the Belgians had modernised their foundries; wages were practically the same

as in this country, but their methods of production were so good that they could turn out castings cheaper and better than we could here. He had seen the Belgian castings; they had a splendid fracture, and better than our own.

With regard to the question of fracture *v.* analysis, this was a point which the Iron and Steel Institute and other societies had been discussing for over sixteen years, and it was the growing opinion among practical men that grading by analysis would have to come. Although the foundryman or the foreman were experienced men, and could tell to a fairly accurate degree by experience and eye what the quality of the pig-iron was, the practice results in a considerable proportion of wasters. He knew a foundry where the pig-iron was actually tested by the way it broke. The grey pig-iron broke fairly easily, the white was a little harder, and the mottled harder still. He did not think they could possibly have a more unsatisfactory state of affairs. That mode of testing might have obtained, say, twenty years ago, when scrap was not used so much. He was perfectly certain that the great trouble, especially in the smaller foundries, was the loose way of grading the pig-irons.

With regard to capturing the world's markets in malleable iron, he did not say that the British malleable trade would again command all the world's trade. We should never do that, but he did say that, if we got on to practical lines, we should get back to a better position in the malleable trade. According to the returns, we were now about fifth, but there was absolutely no reason why we should not be second, though we should never be first. He had emphasised the malleable trade because he saw no reason why it should be centred in the Birmingham area. It was an easy operation—just as easy as grey-work—and grey-iron foundries should take up malleable work. The Research Association would offer them practical assistance in carrying out that work, and by that means they hoped to improve and increase the output of the product. He did not think electric steel would ever take the place of the malleable trade, for many reasons. The electric steel trade was still in its infancy, and for a certain class of castings electric steel would be a long time before it ousted malleable work. The cost of annealing was the great bugbear in the production of malleable work, but when we found that the American Malleable Castings Association—he hoped that the British Cast-Iron Research Association would also take it up—were endeavouring to discover means to do without annealing, it was quite within the realms of possibility that they would eliminate that cost in the manufacture of malleable iron. Professor Touceda, the expert of malleable work in America, considers that it will be possible to produce malleable castings direct from the cupola. He was very pleased to know that malleable cast iron had been produced in the Southern area up to 33 tons tensile strength. That was an extraordinary figure. He had the last report of the Malleable Research Association of America, in which it was said that they had now arrived at the astounding figure of 57,000 lbs. per square inch, and this was universal among foundries which were members of the Association. This represented about 24 tons.

As to semi-steel, he had mentioned it because it was possible the Research Association would take this subject up and thoroughly investigate it, and see how far it could be rendered useful. It was invented by a man named Seaman, in America. Seaman adopted the name because he found that by calling it "semi-steel" it would attract trade better than otherwise. Engineers in America thought it a very fine thing, and the name commanded a good trade. He himself believed that when investigation took place they would find the name "semi-steel" ruled out of existence.

With regard to the electric furnace for foundry work, the American Association, as a result of their research upon the electric furnace as an adjunct to the cupola, found the results obtained were highly interesting. It was found that the electric furnace refined the iron, reducing the sulphur to a negligible amount, and superheating the metal to any desired degree. He quite believed that the electric furnace in duplex work would be adopted

Mr. Faulkner had mentioned an interesting fact with regard to the drying of sands. He was quite certain they had seen in foundries practically no supervision and no preparation of sands. He had been reading a most interesting statement in THE FOUNDRY TRADE JOURNAL about the sands used in the London area, in which it was stated that the reason they made such bad castings was because they had such bad sands, which, of course, was not true. There was no doubt that the drying of sands was an important question, and if this new system were carried out it would probably be of great benefit to them all. The sand problem had been very neglected, and very few foundrymen realised its importance in this work.

He was sorry to find that Mr. Lambert had been depressed by his Paper. If they wanted anything they must use the best arguments to get it, and therefore it was no use him telling them that the foundry trade was in the best possible condition, and at the same time ask the proprietors to join the Association. If it were possible for any of them to take a tour among some of our foundries, they would find that the Research Association had work for the next ten years.

The percentage of failures of castings in America was extremely low. Their Association was formed seven years ago, and for two years they had very few foundries as members. The Research Association had advised a standard method of production, which users had insisted should be carried out by the supplier, and they had had no difficulty in getting all the foundries to fall into line. The same thing would, without doubt, happen in this country.

With regard to the American specification, he could not quite agree that this was not a drastic one. When the specification was first drawn out the whole of the members of the Association in America, with the exception of a very few, petitioned the Association to withdraw it. Later, the same people petitioned the Association to increase the tensile figures. They were quite capable of doing the first specification, and they were rather surprised to find that they could work quite easily to a higher physical test than before.

He had been asked how we should get the employees interested in the work of the Association. One thing which the Government had done, which he thought was very important, was that they asked that employees should be represented on the Councils of these Associations. That was very important, because, as he had said in the Paper, there would be very great changes in the foundry, or else the Association would not do any good. There would be a systematic plan carried out for the trade generally, and they hoped and expected that those foundries who carried it out would benefit by it. Those foundries that did not would come into the category of the survival of the fittest. If they were going to make changes in the working of a foundry, to be carried out by the men in the foundry, surely they should have some voice as to how they should be carried out, and the Government had requested that the employees should have representatives on the Councils of these Research Associations. They had gone to a lot of trouble in this matter, and had asked the unions to make nominations, but had not got a single reply. He asked the moulders and the patternmakers present to approach their unions to send representatives on the Council. There were many reasons for this, but one great reason was that the Association would seriously consider the education of the employee. The Association would approach the whole of the education authorities all over the country with a programme of education for foundry boys, and they would insist upon that programme being carried out. It would be proposed to take the advice of such bodies as the Institution of British Foundrymen in the formation of classes or means of education for boys or anybody engaged in foundry work, and the employees could assist by telling them exactly what was required for foundry work. There was another thing which was equally important. Was there any better practical knowledge of foundry work than that possessed by the foundry employee himself? If the whole of the information held by foundry employees were co-ordinated together it would assist the work of the Research Association, and that was where the employee could assist on the Council.

Trade Talk.

Owing to shortage of coal the management have found it necessary to close down the Mond Nickel Works, Clydach-on-Tawe. This stoppage will affect over 600 men.

The first overseas steamer built by the Australian authorities was launched with great ceremonial last week. It is of 6,600 tons, and one of several ordered by the Federal Government.

It is announced in connection with the reported alternate closing of Messrs. Armstrong-Whitworth's Elswick shops, that the suspension of work only applies to a few departments.

We learn that the proposal recently referred to in our columns to found an Engineers' Club in London is meeting with warm support, and that over a thousand applications have already been received.

At a meeting of the Sheffield Branch of the Institution of British Foundrymen, held on the 16th inst., Dr. E. Rogers delivered a lecture on "Competition Against Castings, and How to Meet It." Mr. J. H. Hyde occupied the chair.

Moulders at the Foden Motor Wagon Works, Sandbach, who had accepted a reduction of wages, have received notices from the Moulders' Union to cease work. The union threatens to expel them if they continue working.

It is reported that no orders have been placed at any Clyde shipyard since February, and that for the first time since Lloyd's Committee was established at Glasgow not a single inquiry regarding new vessels was made during March.

At the recent ordinary meeting of the Institution of Civil Engineers, the following elections were reported:—Members, 10; Associate Members, 41; Associates, 2; transferred from Associate Members to Members, 15; and admitted as students, 13.

After an all-day conference at Carlisle last week between the Shipbuilding Employers' Federation and the Federation of Engineering and Shipbuilding Trades, the men's representatives agreed to recommend the acceptance of a reduction in wages.

Mr. F. M. Parkin, lecturing before the Sheffield Society of Metallurgists and Metallurgical Chemists, expressed the opinion that the comparatively poor quality of coke which was now being supplied would compel steel makers to adopt the gas method.

The Belfast shipbuilding employers have given notice of a reduction in wages of 3s. on time rates and 7½ per cent. on piece rates. No further reduction will be proposed before July next year. The trades unions concerned are considering the proposal.

At a meeting of the Scottish Centre of the Institution of Electrical Engineers, held last week in Glasgow—Mr. E. T. Goslin in the chair—Mr. C. W. Marshall, of the Glasgow Corporation Electricity Department, read a paper on "Continuity of Supply."

A meeting of the Royal Statistical Society was held at the Surveyors' Institution on the 19th inst., when Mr. R. J. A. Pearson read a paper on "A Comparison of Pre-war and Post-war Production Costs in Engineering." Sir R. Henry Rew, the President, was in the chair.

Complete returns for 1920 show that the Canadian shipbuilding industry turned out a total gross tonnage of 204,635, representing 351 vessels of one kind or another. The vessels built and registered in Canada during 1920 numbered 329, including 36 metal vessels.

The intimation that Lord Airedale, Mr. Howarth, of Armstrong Whitworth & Company, and Mr. Dorman, of Dorman & Long, are about to visit N.S.W. simultaneously, suggests that they are investigating the prospects of entering upon iron and steel manufacturing business in the Commonwealth.

The Rotherham Technical Institute Engineering Society held its annual general meeting on the 16th inst., Mr. A. Blenkinsop (president) in the chair. The Secretary (Mr. E. Stansfield) in his report for the year, stated that the Society now contained 151 juniors and 383 seniors, making a total of 534 members.

The report that the Burma Corporation proposed acquiring a controlling interest in "Associated Lead Manufacturers" has, it is stated, created considerable interest in trade circles. The firms connected with this amalgamation are stated to have control of quite 60 per cent. of the lead business in this country.

Replying, last week, in the House of Commons, to Mr. R. Young, Sir A. Mond said that there had been, and still was, a shortage of rain-water and soil goods, and baths, available for housing schemes. The output of light castings had been investigated by a committee appointed under the Profiteering Act, and that committee had recently issued a report, which dealt, amongst other things, with the operations of the National Light Castings Association. Efforts had been made to encourage other makers to undertake the production of the materials of which there had been a shortage, and of substitutes for those materials, and there were indications that output was now improving.

Mail advices from America report that the Steel Corporation produced ingots during March at an average of 51 per cent. of capacity while the Institute steel ingot return, just made, indicates that the independents produced in March at about 31 per cent., making the average for the whole industry 40 per cent.

An open meeting of the Electrical Power Engineers' Association was held on the 16th inst. in Leeds to explain its aims and scope to technically trained engineers holding responsible positions in connection with private plants in industrial works, collieries, institutions, etc., and in the utilisation of supplies from an outside source.

The strike of electricians in Scotland still continues, and is in its sixth week, no conference between the two parties having been held. The employers throughout Scotland have recently been advertising for men at the new rate of 2s. per hour, and there has been quite a considerable number of responses to their advertisements. Some firms are already fully staffed.

The office of the High Commissioner for Australia has received cabled advice that the Commonwealth Cabinet has decided to permit the exportation of metals, alloys, and minerals, including ores and scrap metals, without restriction, provided the contracts of sale are registered with the Australian Metal Exchange in all cases where registration has been required in the past.

The Midland Coal, Coke & Iron Company, Limited, have arranged with Mr. Joseph Gittings, Hill Side, Northfield (in conjunction with Mr. G. B. Richards, 70, Hill Top, West Bromwich), to sell their new brand ("Sinda") of pig-iron. To meet the needs of the district it has been decided to hold a stock of several hundreds of tons so that orders can be despatched without delay.

Professor Hele-Shaw has written to the Government on behalf of the Institution of Mechanical Engineers offering the full co-operation and services of the Institution in the present crisis. The Institution will hold the entire staff and buildings of the Institute in readiness for any purpose in case they are required. This generous offer places at disposal the assistance of a highly-skilled staff.

Mr. W. J. Rees (Lecturer on Refractories at Sheffield University) delivered an interesting lecture at a recent meeting of the members of Sheffield Society of Engineers and Metallurgists at the Applied Science Department, St. George's Square. The president of the Society, Dr. A. McWilliam, was in the chair. The subject of the lecture was "Refractory Materials for Furnaces and Construction Purposes."

Returns of the Employment Exchanges show that throughout the United Kingdom there were approximately 897,053 workers on short time on April 8. The greatest volume of short time working was taking place in the North-Western Division, where 381,558 persons were registered as only partially employed. In Yorkshire and the East Midlands there were 188,454, and in Scotland 90,821.

The National Federation of Iron and Steel Manufacturers have issued the following statement:—The iron and steel industry which normally employs about 300,000 men is faced with the greatest restriction of production which has occurred in its history. The number of blast furnaces in full blast had already been reduced by trade depression from over 300 last August to 109 at the end of March.

Delegate meetings were held last week in various parts of the Black Country of employés in the cast hollow-ware trade in Wolverhampton, West Bromwich, Wednesbury, Dudley, Tipton, and Coseley, to consider the sliding scale proposals recently submitted by the employers. It is understood no definite decision was arrived at, and that a ballot of the whole of the members will be taken on the question.

Sir Peter Rylands, President of the Federation of British Industries, proposing "The Mining and Metallurgical Industries" at the annual dinner of the Institution of Mining and Metallurgy at the Hotel Victoria, said he hoped that the absence from this function of certain distinguished men, who were on the list of speakers on this occasion meant that their services were being enlisted elsewhere in promoting negotiations which would have for their ultimate purpose the restoration of peace conditions in the mining dispute.

The Board of Trade, upon the recommendation of the committee constituted under Section 5 of the German Reparation (Recovery) Act, have ordered that articles imported into the United Kingdom before May 15 next shall be exempt from the provisions of the Act, if it is proved to the satisfaction of the Commissioners of Customs and Excise that they are imported in pursuance of a contract entered into prior to March 8 last, and left the place from which they were consigned to the United Kingdom prior to April 8.

Company News.

Reynolds Bros., Limited. — Capital £3,000 in £1 shares, to carry on the business of ironfounders, etc.

International Nickel, Limited.—Dividend of 1½ per cent. on preferred stock for quarter, payable May 2.

Turvey & Company, Limited, engineers. — Capital £30,000 in £1 shares. Registered office: Holmside, Sunderland.

R. and J. Evans and Company, Limited, shipbuilders. —Capital £20,000 in £1 shares. Registered office: 45, Caryl Street, Liverpool.

Electrical Utilities Corporation, Limited. — Quarterly dividend of 1¼ per cent. on preferred stock for quarter ending March 31.

Amalgamated Engineering Company, Limited. — Capital £6,000 in £1 shares. Registered office: 150, Pinner Road, Harrow, Middlesex.

Chisholm Brothers, Limited.—Capital £1,200 in £1 shares, to take over the business of iron, coal and steel merchants. Registered office: 190, West George Street, Glasgow.

J. Travis, Limited.—Capital £3,000 in £1 shares, to carry on the business of mechanical, electrical and general engineers. Registered office: 8, Nile Street, Burslem.

Geo. Stephenson & Sons, Limited.—Capital £20,000 in £1 shares, to carry on the business of engineers. Registered office: Trent Bridge Works, Newark-on-Trent, Notts.

Reading Foundry Company, Limited.—Capital £6,000 in £1 shares (5,975 participating pref. ordinary and 25 deferred ordinary). Registered office: 16, Holborn Viaduct, E.C.

George Harvey & Company, Limited.—Capital £4,000, to carry on the business of ironfounders. Directors: G. Harvey and G. R. Harvey. Registered office: Chapeltown, near Sheffield.

T. H. Smith (Tipton), Limited.—Capital £5,000 in £1 shares, to carry on the business of iron and brass founders, etc., and to adopt an agreement with L. F. Smith. Registered office: Princes End Foundry, Tipton.

Donald-Bean Insulators & Engineers, Limited. — Capital £15,000, to carry on the business of insulators, ship and boat builders, ship-repairers and outfitters, etc. The first directors are: Messrs. W. H. Donald, A. Bean, and H. London. 11, Great Wellington Street, Glasgow.

Beyer, Peacock, & Company, Limited.—Report for 1920 shows loss on working of £17,270, as compared with an average profit of £77,400 for the past four years. £110,000 is brought forward from 1919, and preference dividend is paid. No ordinary dividend, as against 10 per cent. for 1916-19.

Clayton & Shuttleworth, Limited.—Net profit for 1920, £40,036, to which is added £53,496 brought forward, making £93,532, less interim and final dividend on 5 per cent. preference, leaving £76,032. Dividend proposed on ordinary at rate of 5 per cent. for year (less tax), carrying forward £53,532.

Nautical Engineering (Southampton), Limited. — Capital £20,000 in £1 shares (500 "A," 10,000 "B," and 9,500 "C"), to adopt agreements with the Safety Porthole Company, Limited, and F. Smith & Son (Southampton), Limited. Directors: R. F. Ball (chairman), J. H. Clarke, and J. C. Smith. Registered office: 23, Oxford Street, Southampton.

Keelings Oxides (1921), Limited.—Capital £250,000 in £1 shares; to take over the business carried on by Keelings Oxides, at Stoke-on-Trent and elsewhere, and to carry on the business of winners, crushers, smelters, calciners, and preparers for market of and dealers in ores, metal and mineral substances, etc. Registered office: Fenton.

Duit Engineering Company, Limited. — Capital £2,000 in £1 shares, to carry on the business of motor and general engineers, metal and wood workers, aeronautical engineers and general contractors, etc., and to adopt an agreement with T. B. Friar and J. F. Holdcroft. The first directors are: T. B. Friar, J. F. Holdcroft. Secretary: J. F. Holdcroft. Registered office: 5, Leith Chambers, Quayside, Newcastle.

Sheffield Steel Products, Limited.—Mr. A. H. Wild, presiding at the annual meeting, said that the results achieved fully justified the anticipations made at the meeting in October last. They were now an amalgamation of 21 companies, and the predominant partner was the Templeborough factory at Sheffield. They had the assurance of a world-wide demand for their particular lines, and so great was the demand that even in lean years they were confident of obtaining their share of the world's requirements, especially since they had an advantage over their competitors in lower costs of production. He had been accused of being too optimistic, but every expert who had become acquainted with their methods had been more than satisfied. In spite of criticism they continued to forge ahead, and continued to secure for this country business which would otherwise go to other countries. It might be that Belgian and German steel makers would yet be among their best customers. Their sales for 1921 were so far in excess of those of 1920 that they justified the purchase of the additional businesses, and before long they would be producing everything from the coal down to the finished products.

Gazette.

MR. JUSTICE ASTBURY has made a winding-up order against the Gardiner Shipbuilding & Engineering Company, Limited.

MESSRS. H. BROSTER and A. K. Round, trading as the Broster Sheet Metal Company, Dudley, have dissolved partnership.

A WINDING-UP order has been made against the Stoic Steel & Tool Company, Limited, Self Hard Works, Cornish Street, Sheffield.

ORDERS for the compulsory liquidation of the Crawford Foundry Company and the Portable Electric Motors (1919) have been made in the Companies Winding-up Court.

THE FYLDE ENGINEERING COMPANY, LIMITED, 18, Birley Street, Blackpool, are being wound up voluntarily. Mr. J. Todd, 18, Birley Street, Blackpool, has been appointed liquidator.

MESSRS FREDERICK FLEMING and Arthur William Peach, trading as Frederick Fleming & Company, Dean Street, West Vale, near Halifax, brassfounders and finishers, have dissolved partnership.

MESSRS. A. N. WILKINSON and J. Lewis, general ironfounders, 198, Attercliffe Road, Sheffield, trading under the style of Lewis & Wilkinson, have dissolved partnership. Mr. J. Wilkinson continues under the style of A. N. Wilkinson & Company.

MESSRS. ARTHUR MASSEY, William Thompson, and Richard Yates, trading as the Jarrow Iron & Metal Company, Pitt Street and Queen's Road, Jarrow, marine store merchants and metal brokers, have dissolved partnership. Debts by Mr. R. Yates.

MESSRS. P. F. ROSE, E. R. Pick, R. H. Grubb, A. W. Wigram, H. H. Peel, and R. P. Dodsworth, iron and brass founders and machinists, Fengate, Peterborough, trading under the style of the Peterborough Castings and Engineering Company, have dissolved partnership.

BLACKHALL ENGINEERING COMPANY, LIMITED.—A petition having been presented to the Court of Session at the instance of Wm. Embley, Birmingham, general caster in copper, etc., an interlocutor has been pronounced, dated April 15, allowing answers within eight days after intimation. Martin, Milligan & Macdonald, 2, Albyn Place, Edinburgh, W.S. Mackenzie, Robertson & Company, 176, St. Vincent Street, Glasgow, writers' agents.

RECORD ENGINEERING COMPANY, LIMITED.—It has been resolved March 4, confirmed March 21:—That it is desirable that the company be wound up voluntarily. Mr. S. B. Saunders, 26, Park Row, Nottingham, has been appointed liquidator, and is authorised to consent to the change of names of the Tutbury Engineering Company, Limited, to the Record Engineering Company (1921), Limited, and to the registration thereof, and also authorised to transfer or sell the whole, or any part, of this company's business and property to the Record Engineering Company (1921), Limited.

Personal.

DON RAMON DE LA SOTA, senior partner of Messrs. Sota & Aznar, ore shippers, Bilbao, has been made a Knight Commander of the Order of the British Empire.

MR. H. BEARD, manager of the Gartcosh and Milnwood Works, and Mr. H. Yates, manager of the Mavisbank and Port-Glasgow Works, have been elected to the board of Smith & M'Lean, Limited.

MR. ARTHUR J. BALFOUR has consented to make the presentation of the Kelvin gold medal to Dr. Unwin on Wednesday, May 4, in the hall of the Institution of Civil Engineers, Great George Street, Westminster, S.W.1.

MONSIEUR A. B. CHANTRAINE, inventor of the Chantraine types of multi-flame and rotary flame furnaces and high-efficiency recuperators, has been elected a director of the Smeeton-Wright Furnaces, Limited, 56 Victoria Street, London, S.W.1.

SIR GEORGE B. HUNTER, chairman of Swan, Hunter & Wigham Richardson, Limited, has been the recipient of a handsome presentation from the officials and men in commemoration of his forty years' association with shipbuilding on Tyneside. The presentation was made by Mr. W. Webster, the manager of the company's Southwick yard on the Wear.

IRON AND STEEL MARKETS.

Pig-Iron.

Although entirely unchanged in all essential particulars, the position in the pig-iron markets last week developed something like a spurt, principally, it should be added, on the export side, a fairly substantial order for 3,000 tons of No. 3 Cleveland G.M.B. having been placed for India. There have also been several smaller parcels disposed of for shipment to Scandinavian ports, while other inquiries are anticipated shortly for various foreign destinations when industrial peace is once more proclaimed. These orders will, however, be mostly filled from stocks in maker's yards, production in the Tee-side district being now reduced to an almost negligible quantity. This revival in the export trade is, however, particularly gratifying in view of the fact that that branch of the trade has been almost stagnant for a few months past, and it indicates that we are at last approaching a competitive level of prices. These are now at uniform quotations, both for home consumption and for export, current rates being as follows: No. 1, 125s.; No. 3 Cleveland G.M.B., and silicious, 120s.; No. 4 foundry, 119s.; No. 4 forge and mottled, 117s. 6d.; white, 115s. per ton. The export trade in East Coast hematite is rather more active consequent on the fact that local makers will now accept 160s. per ton for shipment of mixed numbers abroad. The price of West Cumberland and North Lancashire mixed numbers is unchanged at 180s. per ton.

Steel.

The gradual but steady exhaustion of fuel supplies in all the chief centres of the steel industry is having the inevitable effect of closing down production in most branches, very few departments being provided with sufficient stocks of coal to tide over the interval which must elapse before the mines commence working when the present trouble is adjusted. In the meantime business is completely held up, very few prospective buyers showing a disposition to operate in the existing uncertain conditions. At Sheffield the few works in operation are mainly employed in the output of railway material, wagon building, and forgings and foundry work, for which there is at present a renewed demand, but most of these are produced from raw material in hand, no crude steel now being made. On Tees-side the only recent event of note in the manufactured iron and steel trade is the announcement of a further cut of £3 per ton in the price of heavy steel rails and fish-plates, bringing the figures down to £15 and £20 per ton respectively.

Finished Iron.

The disastrous effect of the continued famine in fuel is becoming more and more apparent weekly in the manufacturing departments of the iron trade, nearly all the rolling mills in the Black Country remaining idle, although nut and bolt works, operated by oil, maintain a limited output. Stagnation is now more strongly marked in finished iron, and although the Association quotations remain unaltered there can be no doubt that prices are steadily declining. Meanwhile buying, beyond hand-to-mouth quantities, is at a standstill, conditions likely to continue until some definite assurance on the subject of future fuel supplies is forthcoming. The long-drawn-out negotiations on the miners' dispute is, of course, the main factor in the present depressed state of the finished iron market, but it must not be forgotten that business in this branch has been by no means active for a long time past, and the majority of manufacturers are far from confident of an early revival of demand, even when the existing trouble is settled.

Tinplates.

A revival of overseas inquiries is about the only satisfactory feature to report in the tinplate trade, while there has also been some demand for oil plates and wasters, with certain specifications, particularly light, difficult to obtain. Quarter-plates have been done up to 18s. 3d. f.o.t. Ternes are steady, and business was reported in both heavy and light gauges, the latter round 27s. 6d., basis f.o.b. Orders for plates to be made are still very sparse, and works are not anxious to book at ruling prices as costs of production are not covered. Current prices of tinplates are:—Cokes, 20 x 14, 28s., 31s. 6d.; ditto, quarters, 30s., 31s. Cokes, 20 x 10, 37s., 43s.; ditto, 28 x 20, 53s., 63s Ternes, 28 x 20, 55s.

Metals.

Copper.—The week's markets opened with a steady tone, and with a better outlook in the labour crisis some degree of confidence has been recovered. There is also some evidence of consumers buying on a freer scale in the near future, a more active Continental demand being anticipated as soon as industrial conditions settle down, curtailed production in the States having resulted in the placing of extensive orders for copper in the American market. On forward account May was sold at £70 5s., June £70 10s., the market closing firm with cash on balance 2s. 6d. and three months 5s. higher. Electrolytic was quoted £71 to £74, and wire bars, £73 to £74. Closing prices:—Cash: Wednesday, £70 2s. 6d.; Thursday, £69 7s. 6d.; Friday, £69 17s. 6d.; Monday, £70; Tuesday, £70 5s. Three Months: Wednesday, £70 10s.; Thursday, £69 15s.; Friday, £70 2s. 6d.; Monday, £70 7s. 6d.; Tuesday, £70 10s.

Tin.—Favourable cable advices from the East indicating renewed strength in c.i.f. quotations imparted a corresponding tendency on this side, markets opening with good buying orders, partly on American account, showing an upward tendency in forward dealings. April buying was done at £172 to £174 10s.; May, £174 to £176 10s.; June, £175 to £176 10s.; July, £174 15s. to £176 15s. English ingots closed £5 higher at £170 to £171. The weekly return of stocks of tin in London warehouses reports a decrease of 161 tons to 3,793 tons, while the stock in Liverpool at 2,236 tons has decreased 153 tons on the week. Closing prices:—Cash: Wednesday, £166 15s.: Thursday, £168 15s.; Friday, £168 15s.; Monday, £174; Tuesday, £173 15s. Three Months: Wednesday, £169; Thursday, £171 5s.; Friday, £171 10s.; Monday, £176 15s.; Tuesday, £176 5s.

Spelter.—Business in this market has developed a quiet tendency, near dates showing some weakness, but forward metal unchanged. Sales of late have been in limited quantities, with English spelter marked nominal at £29 10s. Zinc dust, 92-94 per cent., nominal £55 to £60. Zinc ashes, 70 per cent., nominal £6. Ordinary brands, prompt:—Closing prices: Wednesday, £26; Thursday, £26 5s.; Friday, £26 5s.; Monday, £26; Tuesday, £26 5s.

Lead.—With a diminished demand, soft pig declined 7s. 6d. for both near and forward, closing April £20 15s. and August £21 5s. English lead closed 10s. lower at £22 5s.

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CLYDEBRIDGE STEEL WORKS, CAMBUSLANG.
Dalzell Steel and Iron Works, MOTHERWELL.
Head Office: MOTHERWELL.

PLATES, BARS, RAILS and JOISTS.

In Soft, Mild, Medium, High Tensile, H H Tensile, Nickel and Alloy Steel.

DALZELL STEEL
SHIP BRAND

Ground Ganister
FOR EVERY TYPE OF FURNACE.

Steel Moulders' Composition.
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SPECIALITIES:—
RAILS, TRAM RAILS, STEEL SLEEPERS, STEEL JOISTS to 24 in. deep.
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WEEKLY PRICE CURRENT.

COPPER.

	£	s.	d.
Standard cash	70/5/0—70/7/6		
Three months	70/10/0—70/12/6		
Electrolytic	72	0	0
Tough	70	15	0
Best selected	71	0	0
Sheets	116	0	0
India	116	0	0
Wire bars	73	15	0
Do. May	74	5	0
Do. June	74	10	0
Ingot bars	73	0	0
H.C. wire rods.. ..	81	0	0
Off. aver. cash, Mar.	67	13	3¾
Do. 3 mths.,Mar...	67	7	0¾
Do. Settlement Mar.	67	12	8½
Do. Electro. Mar..	71	15	0
Do. B.S., Mar. ..	69	18	10¾
Aver. spot, copper.. Mar.	67	12	7½
Do. Electro, Mar...	72	6	2½
Solid drawn tubes ..		15½d.	
Brazed tubes		15½d.	
Wire		12d.	
Yellow metal rods..		8½d.	
Do. 4x4 Squares ..		10¾d.	
Do. 4x3 Sheets ..		10¾d	

BRASS.

Solid drawn tubes..	13¾d.
Brazed tubes	16¾d
Rods	12¾d.
Sheets to 10 w.g. ..	11¾d.
Wire	11¾d.
Rolled metal ..	11¼d.

TIN.

	£	s.	d.
Standard cash ..	173	15	0
Three Months ..	176	5	0
English	170	0	0
Bars	172	0	0
Chinese	167	0	0
Straits	181	0	0
Australian	180	0	0
Eastern	175	0	0
Banca	189	0	0
Off. aver., cash, Mar.	156	4	7
Do. 3 mths., Mar ..	159	13	1½
Do. Sttlment., Mar.	156	2	1½
Aver. spot, Mar. ..	156	0	3

SPELTER.

Ordinary	26	5	0
Remelted	21	5	0
Hard	16	10	0
Electro 99.9	33	15	0
English	29	10	0
India	19	10	0
Prime Western ..	27	0	0
Zinc dust	55	0	0
Zinc ashes	6	0	0
Off. aver., Mar. ..	25	10	5
Aver., spot, Mar. ..	25	1	6½

LEAD.

Soft foreign ppt ..	20	15	0
English	22	5	0
Off. average, Mar...	19	2	9½
Average spot, Mar	18	18	2½

ZINC SHEETS.

Zinc sheets, spot ..	36	0	0
Do. V.M. ex. whf	36	0	0
Do. ppt., f.o.b., N.Y.		—	
Dutch	35	0	0
Boiler plates	32	10	0
Battery plates ..	32	0	0

ANTIMONY.

English regulus ..	37	0	0
Special brands ..	42	0	0
Chinese	24	0	0
Crude	19	0	0

QUICKSILVER.

Quicksilver.	11	10	0

FERRO-ALLOYS AND STEEL-MAKING METALS.

Ferro-silicon—	
45/50% ..	..17 10 0
75% ..	..25 0 0
Ferro-vanadium—	
35/40% ..	25/- lb. va.
Ferro-molybdenum—	
70/80% ..	10/- lb. mo.
Ferro-titanium—	
23/25%, carbonless	1/6 lb.
Ferro-phosphorus, 20/23%	£32
Ferro-tungsten—	
80/85%, carbon free	1/10 lb.
Tungsten metal powder—	
98/99%	2/3 lb.
Ferro-chrome—	
4/6% car.	£37 10
6/8% car.	£37
8/10% car. ..	£36 0
Ferro-chrome—	
Max. 2% car. ..	£84
Max. 1% car. ..	£100
Max. 0.75% car. ..	£115
65/75%, carbonless	2/9 lb.
Nickel—99·8%, cubes or pellets ..	£195
Cobalt metal—97%..	19/0 lb.
Aluminium—98/99%	£150
Metallic Chromium—	
98/99%	6/6 lb.
Ferro-manganese—	
76/80%, loose ..	£20
76/80%, packed ..	£21
76/80%, export ..	£20
Metallic manganese—	
98/99%, carbonless	3/1 lb.
Per ton unless otherwise stated.	

HIGH-SPEED TOOL STEEL.

	s.	d.
Finished bars, 14% tungsten	3	0
Finished bars, 18% tungsten	3	9
Scrap pieces		5d.
Turnings and swarf..		3d.
Per lb. net, d/d buyers' works.		
Extras—		
Rounds and squares 3 in. to 8 in. inclusive		4d. lb.
Rounds and squares under ½ in. to ¼ in.		3d. lb.
Flats under 1 in. by ⅜ in. to ½ in. by ¼ in., and all sizes over four times in width over thickness		3d. lb.
Bevels of approved sizes and sections ..		6d. lb.
If in coils		3d. lb.
Packing		4s. cwt
Bars cut to length		10% extra
Scrap from high-speed tool steel—		
Scrap pieces		5d.
Turnings and swarf ..		3d.
Per lb. net, d/d steel makers' works.		

SCRAP.

South Wales—£ s. d.	£	s.	d.
Heavy Steel	3	0	0
Bundled steel & shearings	2	15	0
Mixed iron & steel ..1 10 0	4	0	0
Heavy cast iron ..	4	15	0
Good machinery for foundries ..	6	10	0
Cleveland—			
Heavy steel ..	3	5	0
Steel turnings ..	3	0	0
Cast-iron borings	3	0	0
Heavy wrought iron piling	5	15	0
Bundling scrap ..	5	5	0
Cast-iron scrap ..	6	5	0
Lancashire—			
Cast iron scrap ..	6	10	0
Heavy wrought ..	4	0	0
Steel turnings ..	1	10	0
London—			
Copper (clean) ..	49	0	0
Brass (clean) ..	28	0	0
Lead (less usual draft)	16	10	0
Tea lead	14	10	0
Zinc	13	0	0
New aluminium cuttings ..	75	0	0
Braziery copper ..	39	0	0
Gun metal ..	45	0	0
Hollow pewter ..	110	0	0
Shaped black pewter	65	0	0

PIG-IRON.

N.-E. Coast—	
Foundry No. 1 ..	125/-
Foundry No. 3 ..	120/-
Forge No. 4	117/6
Mottled	117/6
Hematite No. 1 ..	182/6
Hematite M/Nos. ..	180/-
Midlands—	
Staffs. common ..	145/-
,, part-mine forge	160/-
,, ,, foundry	170/-
,, Cold blast ..	340/-
,, basic	140/-
Northants forge ..	140/-
,, foundry No. 3	147/6
,, basic.. ..	140/-
Derbyshire forge ..	150/-
,, foundry No. 3	160/-
,, basic ..	150/-
Scotland—	
Foundry No. 1 ..	170/-
,, No. 3 ..	165/-
Hematite M/Nos. ..	180/-
Sheffield (d/d district)—	
Derby forge	155/-
,, foundry No. 3	160/-
,, basic	155/-
Lincs. forge	160/-
,, foundry No. 3	170/-
,, basic	162/6
E.C. hematite ..	193/-
W.C. hematite ..	196/-
All d/d in the district.	
Lancashire (d/d eq. Man.)—	
Derby forge	—
,, foundry No. 3	170/-
Northants foundry No. 3	—
Cleveland foundry No. 3	—
Staffs. foundry No. 3	—
Lincs. forge	172/6
,, foundry No. 3	177/6
Summerlee foundry..	193/-
Glengarnock foundry	193/-
Gartsherrie foundry	193/-
Monkland foundry ..	193/-

FINISHED IRON & STEEL.

Iron—	£	s.	d.
Bars (cro'n)	19	0	0
Angles ..	19	10	0
Tees to 3 united ins. ..	20	0	0
Nut and bolt ..	20	0	0
Hoops	23	0	0
Marked bars (Staffs.) ..	27	10	0
Gas strip ..	22	0	0
Bolts and nuts, ¾ in. × 4 in.	38	0	0
Steel—			
Ship plates ..	19	0	0
Boiler plates ..	25	0	0
Checquer plates	20	0	0
Angles	17	10	0
Tees	18	10	0
Channels ..	18	0	0
Joists	17	10	0
Rounds, ⅜ in.–3-in.	16	0	0
Rounds, 3 in.–5½ in. ..	15	0	0
Flats, 5 in.–8 in.	15	10	0
Flats over 8 in.	15	0	0
Rails, heavy ..	15	0	0
Fishplates ..	20	0	0
Hoops	17	10	0
Black sheets, 24 g.	20	10	0
Galv. cor. sheets, 24 g.	22	10	0
Galv. fencing wire, 8 g. plain ..	26	0	0
Rivets, ¾ in. dia	27	0	0
Billets, soft ..	13	0	0
Billets, hard ..	14	0	0
Sheet and tin bars	13	0	0

PHOSPHOR BRONZE.

Rolled.	Per lb. s.	d.
½ in. to 1 in. wide ..	1	10¾
1 in. to 1½ in. wide ..	1	10½
1½ in. to 2 in. wide ..	1	8¾

Strips.	s.	d.
2 in. to 6 in. to 26 S.W.G.	1	8½
6 in. to 12 in. to 26 S.W.G.	1	8½

Sheets.	s.	d.
12 in. to 18 in. to 24 S.W.G.	1	8½
18 in. to 24 in. to 24 S.W.G.	1	9½
24 in. to 30 in. to 20 S.W.G.	1	10½
30 in. to 36 in. to 16 S.W.G.	1	10¾
36 in. to 42 in. to 16 S.W.G.	1	11¾

Extras.

For Gauge: Any width up to 36 in. wide, ½d. per lb. per thinner gauge.

Drawn Rods.	s.	d.
¼ in. to ½ in. dia. in random lengths / 5/16 in. to 1½ in. dia. in random lengths	1	9
Over 1½ in. to 1¾ in. ..	1	9
Tubes—basis price ..	1	10¾

Delivery 2 cwt. free to any town.

10% phosphor copper, £40 above price of B.S.

15% phosphor copper, £50 above price of B.S.

Phosphor tin (5%), £30 above price of English ingots.

Charles Clifford & Son, Limited, Birmingham.

NICKEL SILVER, SHEET METAL, WIRE AND TUBES.

	Per lb.
Ingots for raising	1/1 to 1/7
Rolled—	
To 9 in. wide	1/8½ to 2/2½
To 12 in. wide	1/9 to 2/3
To 15 in. wide	1/10 to 2/4
To 18 in. wide	1/11 to 2/5
To 21 in. wide	2/- to 2/6
To 24 in. wide	2/1 to 2/7
Ingots for spoons and forks ..	1/1 to 1/7
Ingots rolled to spoon size ..	1/4 to 1/10
Wire round—	
3/0 to 10. G. ..	1/11 to 2/6

with extras according to gauge.

AMERICAN IRON & STEEL.

At Pittsburgh unless otherwise stated.	Dols.
No. 2X foundry, Phila.	26.26
No. 2 foundry Valley..	25.00
No. 2 foundry, Birm. ..	25.00
Basic	24.96
Bessemer	26.96
Malleable	26.96
Grey forge	25.96
Ferro-manganese 80 % delievred	90.00
Bess. rails, h'y, at mill	45.00
O.-h. rails, h'y, at mill	47.00
Bess. billets	38.00
O.-h. billets	38.00
O.-h. sheet bars ..	38.00
Wire rods	52.00
	Cents.
Iron bars, Phila. ..	2.35
Steel bars	2.00
Tank plates	2.00
Beams, etc.	2.00
Skelp, grooved steel ..	2.35
Skelp, sheared steel ..	2.50
Steel hoops	2.75
Sheets, black, No. 28 ..	3.85
Sheets, galv., No. 28 ..	5.00
Sheets, blue an'l'd, 9&10	2.10
Wire nails	3.25
Plain wire	3.08
Barbed wire, galv. ..	3.85
Tinplate, 100-lb. box ..	$6.25

COKE.

Welsh foundry	67/6
,, furnace	55/-
Durham & North. foundry	70/-
,, furnace	42/6
Other Districts, foundry	77/9
,, furnace	45/-

SWEDISH IRON.

	£ s. d.
Bars, hammered basis sizes Basis price	£35 to £37
Rolled Ordinary— Assortment ..	26 0 0 to 27 0 0
Nail Rods— Square, round and flats ..	
Keg Steel / Faggot Steel	about £40 — Prices nominal
Blooms— Single welded ..	£17 to £19
Billets— Single and double welded ..	£20 to £25
Pig-Iron— Grey, white or mottled ..	£14 to £16

Prices are without engagement. All quotations are f.o.b. Gothenburg, net cash against documents there.

TUBES.

	Up to and incl. 2 in.	Over 2 in.
Gas ..	—15%	—20%
Water ..	— 5%	—11¼%
Steam ..	+ 6¼%	— 1¼%

TINPLATES.

I.C. Cokes,	20×14, box	28/–
,,	28×20, ,,	53/–
,,	20×10, ,,	37/–
,,	18¾×14, ,,	30/–
I.X.	,,	73/–
I.X.X.	,,	103–
F.C.B.Y.	21×13⅜ ,,	50/6
C.V.B.G.	16¼×15, ,,	50/–
I.C.W.	20×14, ,,	21/–
,,	28×20, ,,	42/–
,,	20×10, ,,	28/6
,,	18¾×14, ,,	18/3
Terneplates,	28×20, ,,	55/–

DAILY FLUCTUATIONS.

Standard Copper (cash).

	£	s.	d.		
Apr.20	70	2	6	inc.	7/6
,, 21	69	7	6	dec.	5/–
,, 22	69	17	6	inc.	10/–
,, 25	70	0	0	,,	2/6
,, 26	70	5	0	,,	5/–

Electrolytic Copper (Cash).

Apr.20	71	0	0	No change
,, 21	71	0	0	No change
,, 22	71	0	0	No change
,, 25	71	0	0	No change
,, 26	72	0	0	inc. 20/–

Standard Tin (cash).

Apr.20	166	15	0	dec.	25/–
,, 21	168	15	0	inc.	40/–
,, 22	168	15	0	No change	
,, 25	174	0	0	inc.	105/–
,, 26	173	15	0	dec.	5/–

Tin (English Ingots)

Apr.20	162	10	0	dec.	30/–
,, 21	165	0	0	inc.	50/–
,, 22	165	0	0	No change	
,, 25	170	0	0	inc.	100/–
,, 26	170	0	0	No change	

Zinc Sheets (spot).

Apr.20	36	0	0	No change
,, 21	36	0	0	No change
,, 22	36	0	0	No change
,, 25	36	0	0	No change
,, 26	36	0	0	No change

Spelter (ordinary).

Apr.20	26	0	0	No change	
,, 21	26	5	0	inc.	5/–
,, 22	26	5	0	No change	
,, 25	26	5	0	dec.	5/–
,, 26	26	5	0	No change	

Lead (English).

Apr.20	22	10	0	inc.	5/–
,, 21	22	15	0	,,	5/–
,, 22	22	15	0	No change	
,, 25	22	5	0	dec.	10/–
,, 26	22	5	0	No change	

SHROPSHIRE IRON Co., Ltd.

Works:—
Hadley, Shropshire.

Telegrams:—
Sun, Wellington, Salop.
Sunbrand (Cannon), London.

London: 10, Bush Lane, Cannon St., E.C.4.

Telephone:—
11 Wellington, Salop.
5959 Central.

BARS, HOOPS, SECTIONS & WIRE
in IRON, STEEL, COPPER and BRONZE.

Galvanised Telegraph, Telephone, Cable and Trolley Wire
To all Specifications.

Contractors to H.M. Government (Admiralty, G.P.O., India Office, War Office, Colonies), English and Foreign Railways, &c.

BEST H. C. COPPER & BRONZE WIRE a speciality.

Medals:—Sydney (Bronze) 1879, New Zealand (Gold) 1882, Liverpool (Silver) 1886, Adelaide (Gold) 1887, Franco-British Grand Prix (Highest Award) 1908.

ROBERT HEATH & LOW MOOR, LIMITED, Stoke-on-Trent.

B.B.H. IRON.
At works.
BARS, ANGLES, TEES and PLATES.

R.H. ♔ IRON.
Delivered F.O.B. Liverpool.
BARS, ANGLES, TEES and PLATES.

HOOPS delivered F.O.B. Liverpool.

IRON
R.D. ♔
RAVENSDALE (Best)

MILD STEEL (up to 2in. wide)
Marked
"HEATH'S SOFT STEEL."

Prices on Application.

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Telegrams: ALKALIZE, LONDON.
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Head Office:
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REGISTERED TRADE MARK

PIG IRON.

Scotch, Middlesbro,' Hematite, Basic, Specials, &c., &c.

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COPPER — ANTIMONY—MANGANESE.

WILLIAM COLVIN & COMPANY,

ROYAL EXCHANGE, MIDDLESBROUGH.

93, HOPE STREET, GLASGOW.

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THE BRITISH CAST-IRON RESEARCH ASSOCIATION.

DIRECTOR OF RESEARCH.

The Council invite applications for the post of Director of Research to the above Association. Applicants must state age and give full particulars of training, experience in General Metallurgy, especially in Cast-iron Foundry Practice, Laboratory and Research Work, and state salary required.

Applications, endorsed "Director," should be addressed "The Chairman, British Cast-Iron Research Association," and to be received by May 9, 1921.

Canvassing is prohibited.

THOS. VICKERS,
Secretary.

Central House, New Street, Birmingham.
April 16, 1921.

GENTLEMAN, with practical engineering experience as Works Manager, and possessing thorough knowledge of the commercial side of engineering, requires position. Highest references.—Box 555, Offices of the Foundry Trade Journal, Bessemer House, 5, Duke Street, Adelphi, London, W.C.2.

FOUNDRY MANAGER desires change, wide modern experience, Cast and Malleable Irons Crucible Steel (mild), Gunmetal, Aluminium, etc.; expert experience of modern moulding machines (all types) and organisation; can get results; able to introduce new clients, or would consider representing up-to-date firm in London area; age 41; energetic, industrious, of good address, and reliable.—Box No. 734. Offices of the Foundry Trade Journal, Bessemer House, 5, Duke Street, Adelphi, London, W.C.2.

MACHINERY.

TURN TO THE B.W.S. ANNOUNCEMENT, PAGE 10.

FOR SALE.

VERTICAL BORING and TURNING MILL, with 57-in. table, two tool boxes on cross slide, by the Bullard Machine Company.

VERTICAL BORING and TURNING MILL, with 50-in. table, two tool boxes on cross slide, by the Bridgeport Machine Works.

Three Nearly New 24-in. CENTRES, all geared head S.S.S. LATHES, on 36-ft. bed, arranged for Motor Drive, by G. & A. Harvey.

Twelve Nearly New 18-in. CENTRES, all geared Head S.S.S. LATHES, on 34 ft. 3 in. bed, arranged for Motor Drive, by G. & A. Harvey.

36-in. Swing Boring, Surfacing, and Screw-cutting LATHE, by C. Redman & Son.

POWERFUL PLANING MACHINE, to plane 14 ft. by 5 ft. by 4 ft., two tool boxes on cross slide, by J. Buckton & Company.

8 ft. by 3 ft. by 3 ft. Rack-Driven PLANING MACHINE, two tool boxes on cross slide, by J. Butler & Company, Limited.

Three Nearly New No. 3 KEMPSMITH UNIVERSAL MILLING MACHINES, with equipment.

Two No. 2 LUMSDEN OSCILLATING GRINDING MACHINES.

One Internal GRINDING MACHINE, for parallel and taper grinding, by Churchill & Company.

CAPSTAN ENGINES, about 5-in. cylinder, 6in. stroke, 200/250 h.p. Fan Engines and Fans.

STEERING GEARS, Condensing Plant, Generating Sets, Turbines from 2,000 to 10,000 h.p.

ASH HOISTS, Motor-Driven Shunt Wound Geared BOLLARDS.

Large number of WEIR PUMPS, in various sizes, ranging from 6-in. to 14-in. cylinder and 6-in. to 12-in. stroke, with G.M. Valve Boxes.

Double Ram Cameron Type PUMP, two steam Cylinders, 17-in. diam., 15-in. stroke, rams 11-in. diam.

Pair of Double-Acting Cameron Type PUMPS, with steam cylinders, about 17-in. diam. by 12-in. stroke, rams 10-in. diam.

CATALOGUE of STOCK MACHINERY, 5-600 Lots Free on Application. Inspection Invited.

THOS. W. WARD, Albion Works, SHEFFIELD.
Telegrams: "Forward, Sheffield."
Telephone: 4321 (8 lines).

MACHINERY. *Contd.*

HALL'S Invincible Sand Mixer, capacity 1 ton per hour, 18 in. dia., equal to new, suitable for mixing and preparing all kinds of foundry sands at the lowest cost per ton.—Apply, C. E V. Hall, 26, Paradise Square, Sheffield.

FOR SALE.—One Anglo-American Dead-blow, Four-headed Power Hammer, second-hand, for light forgings, 2½-cwt. drop heads, in good working condition; best offers.—Apply to Wilson Bros., Bobbin Company, Garston, Liverpool.

You save money by buying from us!

Lancashire Boiler, 30 ft. x 8 ft., for 120 lbs. w.p.
Loco. Type Boiler, by Robey, 105 lbs. w.p.
5-ton Overhead Foundry Crane, 30 ft. span.
35-h.p. Modern Crossley Gas Engine, "U" Type.
20, 30, 40 and 50-h.p. Electric Motors, 460 Vo. D.C.
Blowers, Fans, Engines, etc. Send your enquiries, Harry H. Gardam & Company, Limited, Staines. 'Phone 98

FOR SALE.—Lathe, in excellent condition, 9 in centre, 16 ft. overall, complete with shafting and pulleys. Suction Gas Engine, 50 h.p. Stockport, cylinder 15 in. dia., 22 in. stroke, in good working order when dismantled.—For further particulars, apply D. D. Evans & Co., Metal Merchants, Pontardulais, Glam.

MISCELLANEOUS.

ORDERS WANTED for small Machine-made Castings in Brass, Gunmetal, Phosphor, or Manganese Bronze. Also Castings any size up to one ton in weight. Prompt delivery.—James G. Crowther, Paradise Street Brass Foundry, Sheffield.

CASTINGS (IRON) ORDERS WANTED for any weight and size (Yorkshire District). Machines if necessary.—Address, Box 728, Offices of the Foundry Trade Journal, Bessemer House, 5, Duke Street, Adelphi, London, W.C.2.

WE Specialise in Aluminium Castings, die and sand. Enquiries solicited. Prompt deliveries. Also Castings in Brass, Gunmetal and Phosphor or Manganese Bronze.—H Perks & Co., 90, Seymour Place, W.1.

ENQUIRIES SOLICITED FOR CASTINGS IN IRON, machined or unmachined, up to 5 cwt. Complete Machines built throughout to specification, singly or in quantity. Jig and Tool Work a speciality.—C. S. Peatfield, Limited, Market Rasen, Lincs.

PATTERNS and CASTINGS SUPPLIED WHICH GIVE SATISFACTION. Inquiries solicited Quotations by return of post or telephone. You can secure good-class work, reasonable prices, and promptitude in delivery by placing your orders with Videx Pattern Works and Foundry, Huntsworth Mews, Upper Baker Street, London, N.W.1. (Telephone, Paddington 364).

FOR SALE, cheap, Foundry Pig Iron, all sections, F.B. Steel Rails, with all accessories; Joists, Channels, Angles, Sheets and Plates, all thicknesses; plumbago.—Ascog, Golder's Green, London. Telephone; Hampstead, 1806.

WE Specialise in FANS and FAN WORK for Foundries. H.P. Fans and Blowers for Smiths' Hearths, Cupolas, Oil and Gas-fired Furnaces, Dust Extraction Fans for Fettling Shop and Sand Blast, Ventilating Fans for Fumes, etc. Worm-geared Pulley Blocks, 10 cwt. to 10 tons.—Progressive Engineering Company, Limited, Leicester.

SWEDISH DEAD SOFT CHARCOAL STEEL, about

2 tons	5/16 in.	round	Price £21 or offer. Delivery ex stock.
3 ,,	13/16 in.	,,	
3 ,,	⅜ in.	,,	
3½ ,,	7/16 in.	,,	
4 ,,	⅜ in.	,,	
8 ,,	⅞ in.	,,	
8 ,,	15/16 in.	,,	

Ivar Forssberg, 110, Cannon Street, E.C.4.

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